AD-A139 768 MANUFACTURING METHODS AND TECHNOLOGY PROJECT SUMMARY REPORTS(U) ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY ROCK ISLAND IL DEC 83 1/3

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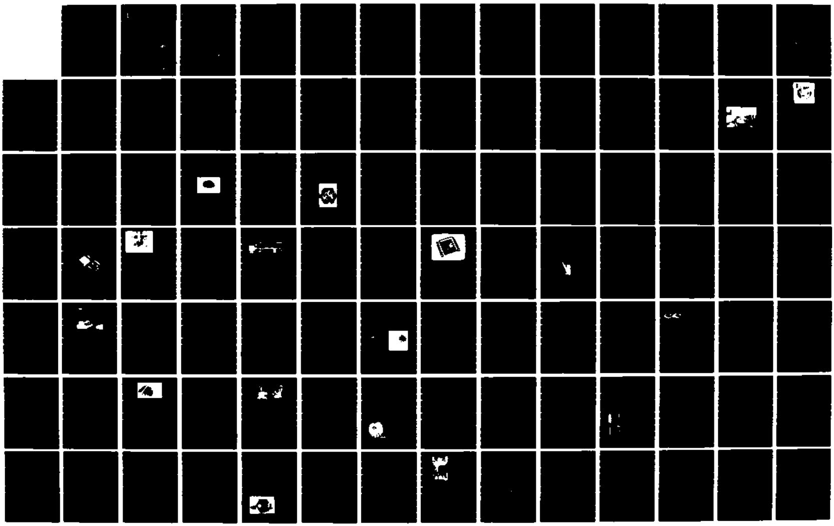

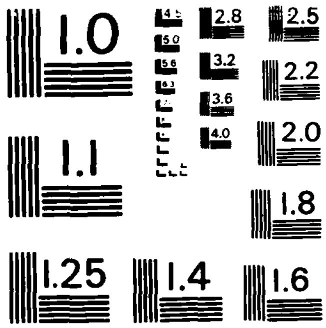
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US ARMY

MATERIEL DEVELOPMENT AND READINESS COMMAND

DIRECTORATE FOR MANUFACTURING TECHNOLOGY

MANUFACTURING METHODS & TECHNOLOGY

PROJECT SUMMARY REPORTS

(RCS DRCMT-302)

DECEMBER 1983

PREPARED BY

USA INDUSTRIAL BASE ENGINEERING ACTIVITY

MANUFACTURING TECHNOLOGY [illegible]

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This report contains summaries of 105 projects that were completed under the Army's Manufacturing Methods and Technology (MMT) Program. The MMT program was established to upgrade manufacturing facilities used for the production of Army Materiel. The summaries highlight the accomplishments and benefits of the projects and the implementation actions underway or planned. Points of contact are also provided for those who are interested in obtaining additional information.

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DEPARTMENT OF THE ARMY
US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
ROCK ISLAND, ILLINOIS 61299

REPLY TO
ATTENTION OF:
DRXIB

13 December 1984

SUBJECT: Manufacturing Methods and Technology Program Project Summary Report (RCS DRCMT-302)

SEE DISTRIBUTION (Appendix II to Enclosure 1)

1. In compliance with AR 700-90, dated 15 March 1982, the Industrial Base Engineering Activity (IBEA) has prepared the enclosed Project Summary Report.

2. This Project Summary Report is a compilation of MMT Summary Reports prepared by IBEA based on information submitted by DARCOM major subordinate commands and project managers. These projects represent a cross section of the type of efforts that are being conducted under the Army's Manufacturing Methods and Technology Program. Persons who are interested in the details of a project should contact the project officer indicated at the conclusion of each individual report.

3. Additional copies of this report may be obtained by written request to the Defense Technical Information Center, ATTN: TSR-1, Cameron Station, Alexandria, VA 22314.

1 Encl
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James W. Carstens
JAMES W. CARSTENS
Chief, Manufacturing Technology Division

TABLE OF CONTENTS

CAD/CAM

No projects under this category in this issue.

ELECTRONICS

Tables of Contents (Continued)

Tables of Contents (Continued)

Tables of Contents (Continued)

Tables of Contents (Continued)

Page

NON-METALS

Tables of Contents (Continued)

INTRODUCTION

Background

The Manufacturing Methods and Technology (MMT) Program was established to upgrade manufacturing facilities used for the production of Army materiel, and as such, provides direct support to the Industrial Preparedness Program. The Manufacturing Methods and Technology Program consists of projects which provide engineering effort for the establishment of manufacturing processes, techniques, and equipment by the Government or private industry to provide for timely, reliable, economical, and high-quality quantity production means. The projects are intended to bridge the gap between demonstrated feasibility and full-scale production. The projects are normally broad based in application, are production oriented, and are expected to result in a practical process for production. The projects do not normally include the application of existing processes, techniques, or equipment to the manufacture of specific systems, components, or end items, nor do they apply to a specific weapon system development or a product improvement program.

MMT Program Participation

MMT Programs are prepared annually by DARCOM major subordinate commands. These programs strive for the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and projected programs.

Project proposals (Exhibits P-16) are submitted to the appropriate MMT Program Office. A list of offices is provided in Appendix I. Additional information concerning participation in the MMT Program can be obtained by contacting an office listed or by contacting Mr. James Carstens, AUTOVON 793-5113, or Commercial (309) 794-5113, Industrial Base Engineering Activity, Rock Island, IL 61299.

In anticipation of the lengthy DOD funding cycles, projects must be submitted in sufficient time for their review and appraisal prior to the release of funds at the beginning of each fiscal year. Participants in the program must describe manufacturing problems and proposed solutions in Exhibit P-16 formats (see AR 700-90, 15 March 1982, for instructions). Project manager offices should submit their proposals to the command that will have mission responsibility for the end item that is being developed.

Contents

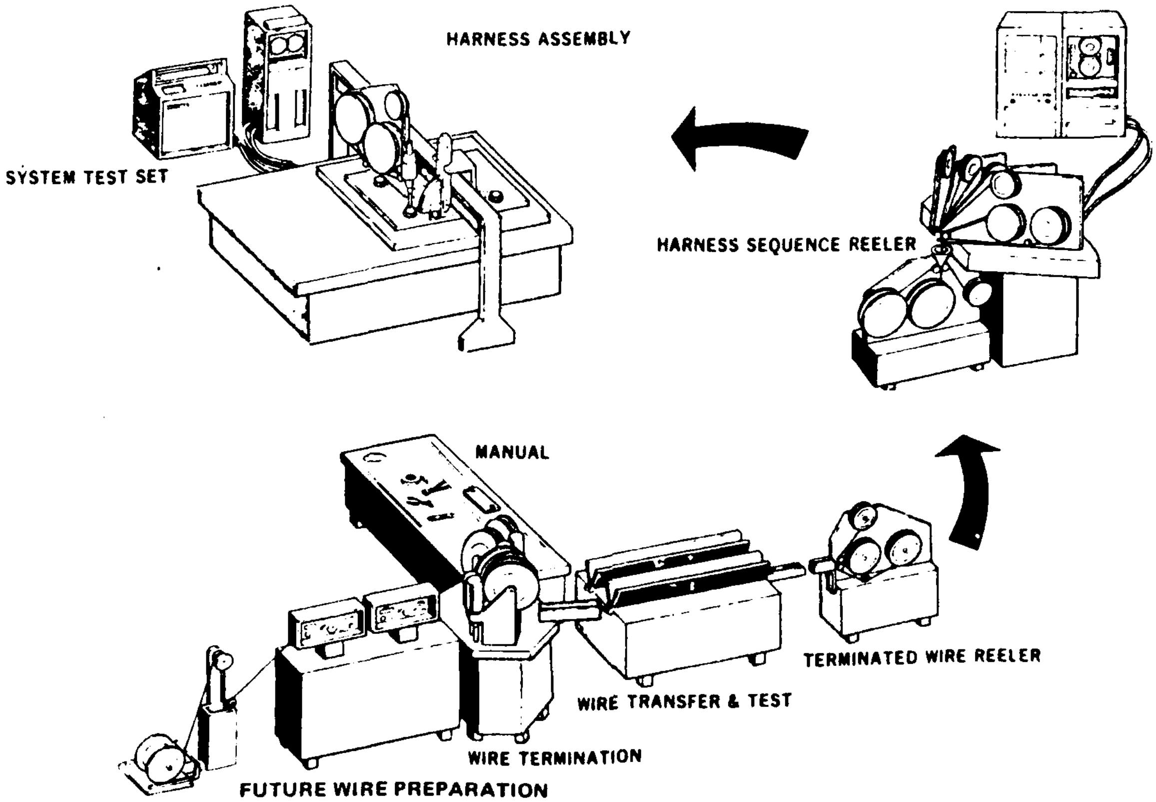
This report contains summaries of 105 completed projects that were funded by the MMT Program. The summaries are prepared from Project Status Reports (RCS DRCMT-301) and Final Technical Reports submitted by organizations executing the MMT projects. The summaries highlight the accomplishments and benefits of the projects and the implementation actions under way or planned. Points of contact are also provided for those interested in obtaining additional information.

The MMT Program addresses the entire breadth of the Army production base and, therefore, involves many technical areas. For ease of referral, the project summaries are grouped into six technical areas. The technical areas are: CAD/CAM, Electronics, Inspection and Test, Metals, Munitions, and Non-Metals. A page of abstracts leads off each of these groups. Abstracts were prepared to highlight projects which achieved significant accomplishments.

This report was also organized and bound to facilitate its disassembly. A disassembled report may be used to selectively circulate certain summaries and for filing of selected summaries for future reference.

The Summary Reports are prepared and published for the Directorate for Manufacturing Technology, DARCOM, by the Manufacturing Technology Division of the US Army Industrial Base Engineering Activity (IBEA) in compliance with AR 700-90. The report was compiled and edited by Mr. Andrew Kource, Jr. and ably assisted by Ms. Eileen Griffing and Ms. Sally Weckel with the typing and graphics arrangements.

ELECTRONICS



CONCEPTUAL APPROACH TO FIXING

ELECTRICAL CONNECTORS TO CABLES

ABSTRACTS

Project Number	Project Title	Page
276 9746	MM&T Engineering Measure for the Production of Thin Film Aluminum Oxide Ion Barrier for 18mm Microchannel Plates	E-3

When operating Night Vision Goggles, electrons impact the microchannel plate (MCP) and generate positive ions, which in turn degenerate the photocathode. This project developed a method of applying aluminum oxide to the MCP to eliminate positive ion release. The process integrated cleaning, polishing, chemical etching, lacquering, aluminum oxide application, and inspection techniques. The results have been an increase in goggle life from 2000 to 7500 hours and widespread industry interest.

580 1003	MMT, Low Cost Molded Packaging for Hybrid Electronics	E-9

Typically, hybrid circuits installed in artillery, mortar and rocket fuzes have been foamed or epoxied in place, but not hermetically sealed. This project developed a system to imbed hybrid circuits in a special protective resin without damage to the circuit. The rigid epoxy was preheated and forced into a cavity surrounding the circuit. A go/no-go electrical test indicated a 95 percent success rate on the imbedded circuits at a cost savings of $.20 per fuze.

H79 3516	Cooler Motor Hybrid Circuit	E-20

This effort focused on the development of more economical techniques for the production of the motor drive hybrid circuit for small split-cycle Sterling cryogenic coolers. Automatic wire bonding techniques were implemented, pin swaging and soldering process control was improved, and a protective fiberglass hybrid cover was designed. Production rates were greatly increased and the unit selling price was reduced from $550 to $150.

Page

Third generation low cost image intensifier tubes for night vision goggles are a significant improvement over conventional tubes but are much more expensive to produce. This effort established the manufacturing capability for third generation image intensifier tubes by improving liquid phase epitaxial growth processes, refining thermocompression bonding techniques, controlling sputtering system and lacquer-electron beam film deposition thicknesses, and developing test procedures. Total cathode yield was increased from 4 percent to slightly over 30 percent.

Microelectronic hybrid circuits used in missile systems are hermetically sealed in metal packages. Trial set-up runs and long vacuum bakes are required for redrying if a package must be resealed to eliminate leaks. Six companies participated in this project to produce a closed loop system which tests packages and allows resealing without exposure to room atmosphere. Packages are oven baked, hermetically sealed by parallel seam welding, gross lead tested and returned for rework, if necessary, in a dry nitrogen/helium atmosphere, yielding a significant cost reduction per package.

This project identified and addressed selected thick-film power hybrid areas to enhance producibility and lower production costs. A low cost, reworkable backing layer/solder system was developed for substrate to header attachment, reducing material costs by 50 percent. The capability for bonding heavy aluminum wire to gold was produced and equations for determining the cost effectiveness of chip resistors vs. screened resistors were derived. Project results have been incorporated into many DOD systems, including TPS-43, 63, 70 radars, ECM and marine radar.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **276 9746** titled **"Manufacturing Methods and Technology Engineering Measure for the Production of Thin Film Aluminum Oxide Ion Barrier for 18MM Microchannel Plates"** was completed by the US Army Electronics Research and Development Command in July 1980 at a cost of $480,000.

BACKGROUND

The 18MM image intensifier tube used in night vision goggles had a relatively short life of 2,000 hours because of an inherent fault. In operation in the Night Vision Goggles, electrons impact on the microchannel plate (MCP) and generate positive ions. These ions reach the photocathode and cause its slow degradation which limits the tube life to approximately 2,000 hours. If the ions are kept from reaching the photocathode, tube life could be increased 4 to 10 times.

SUMMARY

The purpose of this project was to develop manufacturing techniques for depositing a thin film of aluminum oxide (Al_2O_3) onto the input surface of 18MM Microchannel Plates (MCP) used in second generation direct view image intensifier tubes. This thin film of aluminum oxide acts as a physical barrier to positive ions generated in the MCP as a result of electron impacts while permitting free passage of electrons from the photocathode. The MCPs used in 18MM image intensifer tubes did not have such a barrier and ions reaching the photocathode resulted in slow degradation. The new film physically prevents ions from reaching the photocathode and increases tube life three to four times.

A summary of steps needed to apply a film to a microchannel plate are shown in Figure 1. First, the MCP is cleaned in a proprietary process, chemically etched to remove polishing marks, and then hydrogen fired to provide a high initial strip current, and vacuum baked at 375°C for 16 hours. It is electroded by plating a metal conductor around its rim and after inspection and sample lot testing, is ready for lacquer application. A film of lacquer is obtained by floating a clean, liquid lacquer onto a dust-free water surface. Water temperature is controlled to determine drying rate and thus thickness of the film. A film thickness of about one mil is desired. The clean MCP is inserted into the water and brought up under the film to cause the lacquer to adhere to its surface.

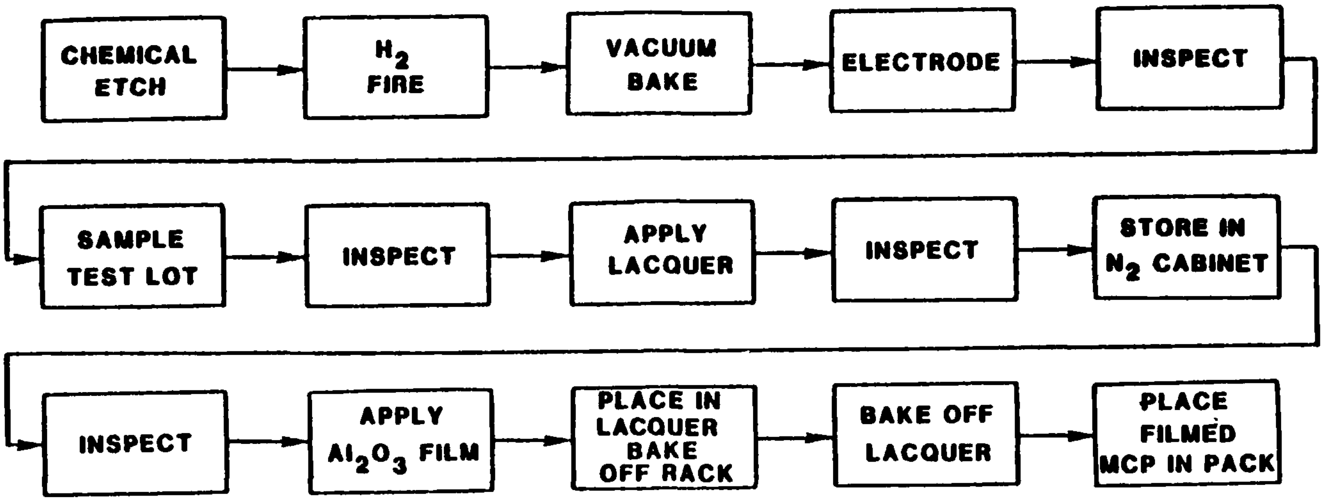


Figure 1 - Al_2O_3 Filmed MCP Fabrication Process

After several inspections and storage in a dry nitrogen cabinet, the MCPs are ready for aluminum oxide (Al_2O_3) filming. Aluminum oxide is electron beam evaporated (deposited) onto the lacquer film in a Varian or other evaporator evacuated by ion and sublimation pumps. Film thickness is monitored by a crystal monitor and deposition is controlled by a special dual shutter arrangement. The MCPs are not exposed to Al_2O_3 vapor until the evaporation rate is adjusted properly. Start and stop of deposition are accurately controlled by sequentially opening and closing the two shutters to obtain the desired 40 to 50 Angstrom thickness on a highly reproducible basis. Finally, removal of the lacquer is accomplished by baking in an air atmosphere.

Quality and integrity of the ion-barrier film is important to its effectiveness as a stop against ion poisoning. Several inspections are made to the films during processing to assure hole-free films before proceeding with the next step; these inspections are shown on the flow chart.

Another step important to the quality of the film is polishing of the input face of the MCP. During the contract several polishing methods were investigated: fire polishing and mechanical polishing. Fire polishing involves exposing the MCP to a radiant source which heats the glass above its flow temperature and permits surface tension to level the glass. Application of heat was not worked out adequately and this method was abandoned. Mechanical polishing was tried in several forms. Finally, a slow polish with reduced pressure, different cerium oxide polishing compound and heavier slurry suggested by NV&EO Labs proved effective.

Several other processes were found to be important to the quality of the MCP; slicing, grinding and polishing of MCPs were improved based on suggestions from Army Night Vision and Electro-Optics Labs. Slicing marks were mostly eliminated by reducing the blade pressure, thickening of the silicon carbide grit, and running the slurry pump continuously. Grinding was enhanced by beveling the edge of the MCP to prevent chips from breaking off and scratching the surface during grinding and by reducing grinding pressure and thickening the slurry.

BENEFITS

The benefits derived from this project include proven methods for slicing, grinding, and polishing microchannel plates, methods for applying an aluminum oxide barrier film to the input side of the MCP, and techniques and equipment for testing the improved microchannel plates. As a result of this contract the specification for tube life has been increased from 2,000 hours to 7,500 hours, minimum. The life cycle cost of the 18MM Goggles has thus been reduced 3.7 times.

IMPLEMENTATION

The methods and equipment adapted for grinding, polishing and filming microchannel plates are used in production at the contractor plant, ITT Electro-Optical Products Division, Roanoke, VA. The project was thus self-implementing. A final report is available to qualified individuals who would like to study and follow the new methods and a Classified Addendum is available to approved applicants. The Contract Number is DAAB07-76-C-0043.

The project engineer discussed program results with five firms involved in the production or application of microchannel plates. These include Galileo Electro-Optics Corporation, Sturbridge, MA, Litton Industries, Tempe, AZ, Ni-Tec Corporation, Niles, IL, Varian Associates, Palo Alto, CA, and Varo Incorporated, Garland, TX. Several firms have started materials, process and fixturing improvements based on results of this project and the tech transfer initiated by the project engineer.

MORE INFORMATION

Additional details may be obtained from Mr. Ed Bender, Night Vision and Electro-Optics Laboratory, Attn: DELNV-SE (Mr. Bender), Ft. Belvoir, VA, 22060, AUTOVON 354-1624 or Commercial (703) 664-1624.

Summary report, Dec 83, was prepared by C. McBurney, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **277 9811** titled **"Reduction of Manufacturing Cost for Microwave Power Transistors and In-Process Tuning"** was completed in September 1979 by TRW for Harry Diamond Laboratories and the US Army Communications and Electronics Command at a cost of $600,000.

BACKGROUND

When this project was conceived in 1975, ten and twenty watt microwave transistors for use at S-band (2.6 to 3.9 gigahertz) were rare, high cost items. High cost resulted from the large amount of skilled labor needed to wire input and output circuit components to match the internal impedance of the individual transistor. This was done by wire bonding a number of resistor and inductor elements to the transistor's collector and emitter. A small commercial market and unstable military market did not encourage company investment in automated equipment to select and bond inductor elements to transistor components. What was needed was a computerized impedance measuring system and software for selecting the proper inductor elements, and automated means for bonding them to the transistor.

SUMMARY

The work at TRW Semiconductor, Lawndale, CA, included reconfiguration of an early commercial 10 watt 2 GHz transistor design L-10 to a new design more amenable to automated assembly and wire bonding. The new integrated configuration is illustrated in Figure 1, and an enlarged view of the center unshaded area is shown in Figure 2.

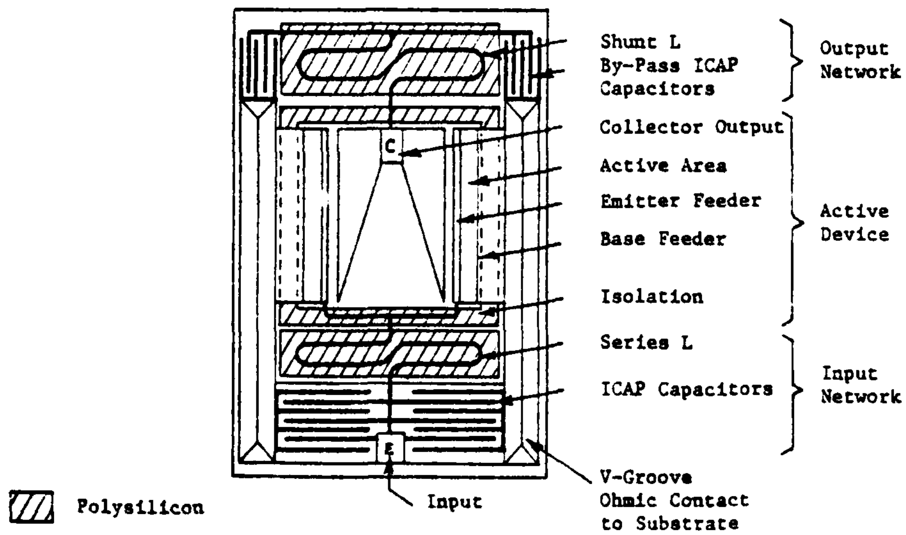


Figure 1 - L-10, 10 watt, 2 GHz Transistor

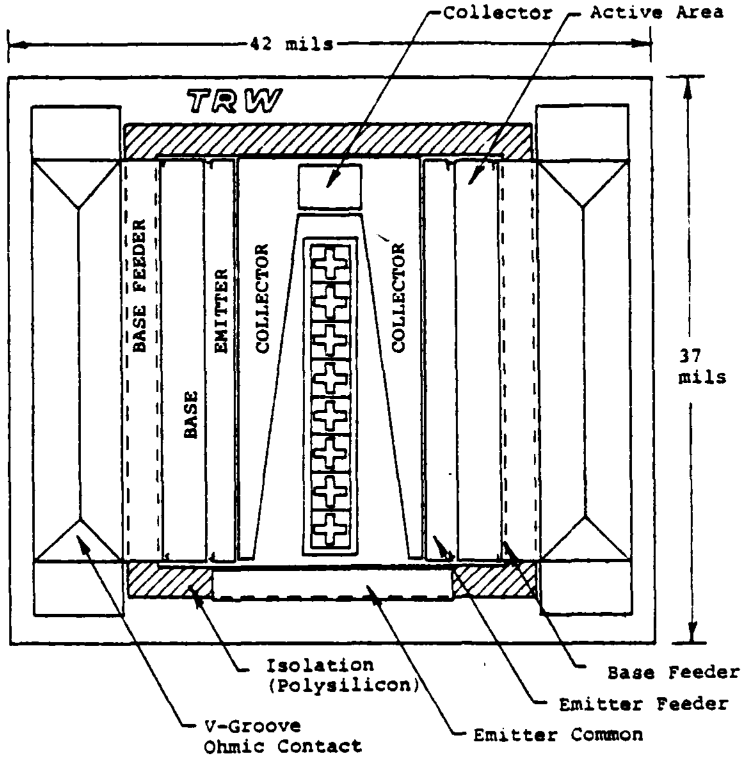


Figure 2 - L-10 Device Layout

Planar top-contact units having V-grooves for isolation and contact to the substrate were developed and fabrication techniques worked out. An impedance matching network consisting of monolithic inductors and capacitors was diffused into the silicon wafer similar to the way the transistor emitter, base and collector elements are. A cutaway view of the transistor configuration is illustrated in Figure 3. This manufacture of the matching elements at the same time and in the same wafer as the transistor elements is of prime importance to driving down the cost of high frequency, high power transistors and was a breakthrough for its time.

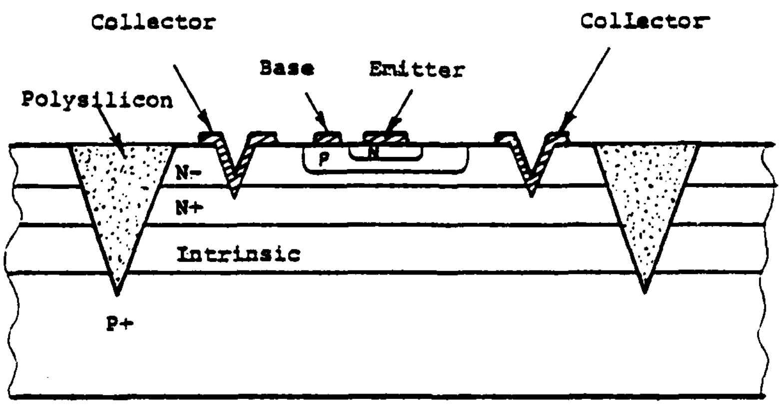


Figure 3 - Cross Section of Final Device Fabrication

In addition to developing V-groove construction and applying computer controlled wirebonding, several processing problems were overcome during the operation of this contract:

a. Where the conventional photoresist process was unusable in the presence of the V-groove, fine geometry metallization was done prior to V-grooving,

b. Where plating of a platinum silicide contact in the V-groove was not possible, plating of an aluminum, titanium, tungsten, gold contact system worked satisfactorily,

c. Where standard passivation of gold would not withstand the V-groove etchant, a reactive metal interface was developed to give the gold the adhesion needed to withstand the etchant.

d. Where the present mask set did not permit post via processing, the masks were redesigned to permit this process, and

e. Where the single sided collector RF resistance was a problem above 1.5 gigahertz, epitaxial layer thickness and resistivity were changed to reduce this resistance.

BENEFITS

The contractor was not completely successful computerizing the selection and bonding of variable inductor and capacitor elements to the transistor emitter and collector components. The computerized selection of impedance values was satisfactory but the automated bonding of inductor and capacitor elements was not worked out completely because of lack of funds. The contract had a "best effort" clause and funds were depleted before the automation could be worked out.

IMPLEMENTATION

The successful portion of this contract is in partial use at TRW Semiconductors where it is applied to the testing of input and output impedance values for microwave power transistors.

MORE INFORMATION

The quarterly and final contractor technical reports were entitled "Monolithic 20 Watt 2 GHz Transistor and 5 Watt 4 GHz Transistor," and are available from DDC or NTIS using the contract number as an identifier: DAAB07-77-C-0431. The reports are approved for public release.

Summary report, Dec 83, was prepared by C. McBurney, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **580 1003** titled "**MMT, Low Cost Molded Packaging for Hybrid Electronics**" was completed by the US Army Armament Research and Development Command in December 1982 at a cost of $243,000.

BACKGROUND

Hybrid circuits used extensively for artillery, mortar, and rocket fuzes must withstand high g shock and acceleration. They are now foamed or epoxied in place, but this does not provide hermetic protection. Hermetic packages are not used due to cost considerations. This project applied molding techniques now used for making dual-in-line plastic packages to larger hybrid circuits.

SUMMARY

Springborn Laboratories Incorporated was tasked to identify and evaluate candidate embedding resin and molding process combinations, suitable for high speed, low-cost hybrid electronics packages. These candidate systems were to be functionally adaptable for embedding hybrid circuits at a 5000 unit per eight-hour day production rate.

The M734 fuze amplifier was considered a representative thick film hybrid and was selected for this prototype molding study. It has small discrete tantalum and ceramic capacitors and precoated chip and wire-bonded components.

Four sets of materials/processes were evaluated by special tests and molding trials. These sets were the following:

(1) Rigid Epoxy (G.E. PTX-1200): Transfer Molding.

(2) Rigid Epoxy (Eccomold LTM-2850): Transfer Molding.

(3) Flexible Silicone (G.E. LIM-2600): Liquid Injection Molding (LIM).

(4) Flexible Urethane (Upjohn CPR 2164-75A): Reaction Injection Molding (RIM).

Transfer molding of a rigid epoxy, PTX-1200 G.E. Company, showed the most promise and was used to encapsulate 150 M734 fuze amplifier circuits.

The equipment utilized for the transfer molding trials was a 25 ton clamp-size transfer press with 13 x 18 inch horizontal platens. See Figure 1. Its transfer pot was loaded with a 25g (14 cm^3 volume) preform for a single cavity mold. The epoxy preform was preheated dielectrically to

90°-100°C and transferred under pressure from transfer pot to mold cavity. The hybrid circuit was secured in the mold by fixturing pins and centering rod. Molding success was defined in all processes as satisfactory electrical performance of the fully embedded circuit.

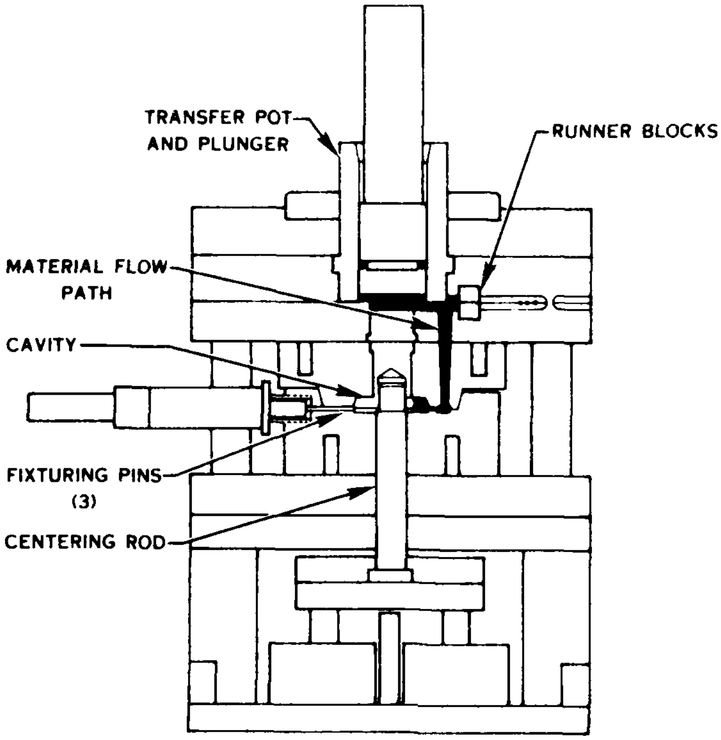


Figure 1 - Mold Configuration-Transfer Molding

A go/no-go electrical test was devised to check the circuit integrity before and after molding. Twenty five volts DC was applied to specific device probe points and current drawn was measured. Acceptable current magnitude was determined as approximately 8-10 milliamperes in forward and reverse polarity. Tested units with current differing by a significant amount after molding were designated as no-go. Units failing the test usually had cracked substrates or displaced components.

Based on trial results, the mold was modified to include a top gate system and 8 bottom support pins to engage the substrate during the initial mold cycle. Mold trials made with these improvements yielded no cracked substrates and a 95 percent success rate. Transfer molding 150 M734 hybrid electronic circuits successfully demonstrated techniques and prototype mold that could be scaled up for production to 5000 molded circuits per 8-hour day.

BENEFITS

A successfully molded hybrid package should result in a cost savings of approximately $.20 per fuze. Conservative 50,000 per month production rates for the M734, M732, or M724 fuzes would yield an annual $120,000 savings per year, per fuze type.

IMPLEMENTATION

The results of this project were well documented and are available for implementation. Molding techniques and materials developed under this contract are being considered for encapsulating the M732 fuze power supply.

MORE INFORMATION

Additional information may be obtained from Mr. Allan B. Goldberg, Harry Diamond Laboratories, Adelphi, MD, AUTOVON 290-3114 or Commercial (202) 392-3114.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **580 1005** titled **"Ceramic-Metal Substrates for Hybrid Electronics"** was completed by the US Army Armament Material Readiness Command and Harry Diamond Laboratories in September 1983 at a cost of $319,000.

BACKGROUND

Recently wide interest has been aroused in the hybrid microelectronics industry by the introduction of the insulated metal substrate (IMS) as an alternative to alumina.

IMS substrates can be tailored for specific applications to achieve high heat transfer or to match a particular thermal expansion coefficient. Some additional IMS advantages are the following:

(1) Strength.
(2) Large size with high yield and low cost.
(3) Machinability.
(4) Surface smoothness.
(5) Adaptability.

Despite many attractive features, the IMS concept has been slow in gaining acceptance, especially for complex military hardware. In short, industry has failed to establish the manufacturing controls and processes for substrates, film materials, and assembly techniques suitable for high-volume production.

SUMMARY

This project's objective was to establish the methods and processes needed to manufacture ordnance hybrids, using insulated metal substrates.

Westinghouse Electric Corporation, Defense Electronics Center, at Baltimore, Maryland was contracted to perform and detail the required manufacturing technology. Work was divided into three functional tasks. The elements which comprise a hybrid circuit were individually evaluated and the results were applied to the M734 hybrid circuit fuze amplifier used by the Army in large quantities.

Phase I was concerned with substrates. Various IMS concepts including porcelain enameled steel (PES), ceramic sprayed on metal, and anodized aluminum were investigated. The substrate selected for pilot production was 2 x 2 inch PES from Erie Ceramic Arts (ECA). Core material was conventional porcelainizing steel.

Phase II was involved with characteristics of thick films processed on the IMS selected in Phase I. Conductor, dielectric, and resistor inks were purchased in the open market for this testing. Effects of peak firing temperature wetting, leach resistance, and adhesion were investigated. Minimum line widths and spacings, limitations on printed resistor size, solder pad area and thickness requirements and overall thick-film compatibility with the PES substrate were verified.

Phase III reviewed device packaging which included chip attachment, thermosonic wire bonding, encapsulation, molding, shielding, electrical interconnection, protective covering and mounting to support structures. See Figure 1. PES hybrid construction elements necessary for function and survivability in fabrication, test, storage and use were evaluated. Results were utilized to fabricate the hybrid circuit M734 fuze amplifier with approximately 75 percent yield. Ten complete amplifiers were delivered to HDL for electrical test. See Figure 2. Electrical tests performed included bridge current, oscillator B+, reset-timer, arming time, and disable voltage. The PES-based fuze amplifier performance in these tests was identical to that of alumina-based amplifiers.

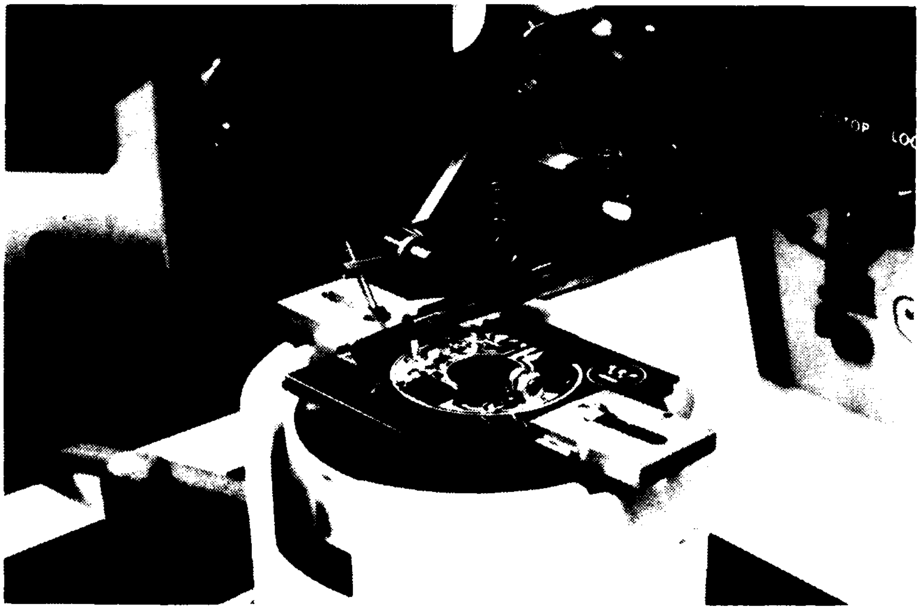


Figure 1 - Closeup of Substrate Mounted for Wirebonding

Final results revealed that a thick film PES hybrid circuit could be processed through most high volume operations with acceptable efficiency. Only in wirebonding was there a serious question as to PES substrate applicability. Time and funding limitation precluded complete resolution of the problem. Features such as wire hardness, capillary shape and capillary temperature could be optimized to obtain improvement. Denser gold films and substrates with higher firing temperature would also contribute to resolution of the discrepancy.

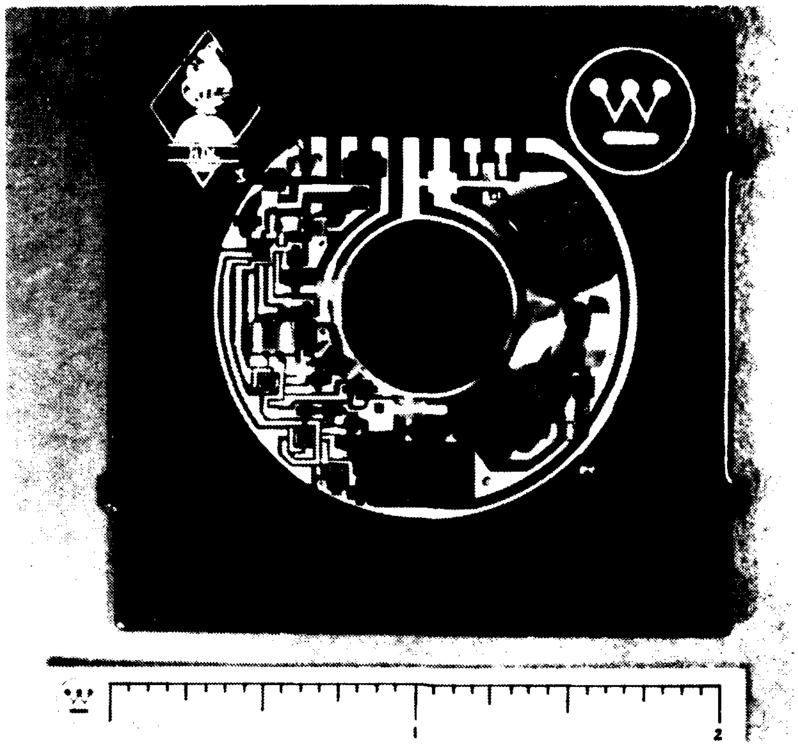


Figure 2 - Completed M734 Fuze Amplifier Assembly

BENEFITS

The feasibility of building ordnance hybrids on PES substrates was demonstrated and areas where development is necessary were clarified. Although all goals were not attained, sufficient work was performed to advance the technology to the point where subsequent applications will be much easier.

IMPLEMENTATION

The results of this effort will be expanded in follow-on MMT projects 5 83 1800 and 5 85 1800. A Final Technical Report Number HDL-CR-83-076-1 was distributed to both industry and government.

MORE INFORMATION

Additional information may be obtained from Mr. Albert Lee, Harry Diamond Laboratories, Adelphi, Maryland, AUTOVON 290-2840 or Commercial (202) 392-2840. The contract number was DAAK21-80-G-0076.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **E78 3604** and **E79 3604** titled **"Development of Manufacturing Methods and Technology for a Solid State Power Switch"** were terminated by the US Army Mobility Equipment Research and Development Command in June 1982 after expending $259,000 and $32,000, respectively.

BACKGROUND

Prior to contract award Delta Electronics Control Corporation, now Helionetics Incorporated, had developed a fast, efficient, high-voltage solid state switch using thick film technology. The device utilized multiple parallel pass transistor chips and control circuitry installed on a common heat sink. The switch was originally fabricated in small quantities under a government R&D program.

Manufacturing techniques were now needed for large quantity production. An immediate application was for power inverters through the 5 KW size.

SUMMARY

The project's objective was to establish a production capability for reliable solid state power switches (SSPS). Helionetics modified the SSPS design for production by electrically insulating the transistor chips from the heat sink and substituting a hermetically sealed case for the silastic encapsulation. Input bias voltages were changed from ± 5 VDC to ± 7 VDC and an additional control terminal was added to enhance control and increase application. Overload protection was also included. Switch specifications are described below:

SSPS SPECIFICATIONS

Voltage (emitter-collector)	250 Vdc operating 300 Vdc maximum
Saturation voltage	1.5 Vdc maximum
Current	50 amps continuous 100 amps peak
Control power	±7 Vdc @ 200 mA
Control signal	Short to switch common for turn on (10 mA)
Turn-on delay	1 microsecond maximum

SSPS SPECIFICATIONS (Continued)

Turn-off delay	1 microsecond maximum
Rise and fall times	250 nanoseconds
Dimensions	3"x2"x1/2" exclusive of terminals

Switch construction equipment was purchased and evaluated. Jigs and test fixtures were designed and built, and sampling and test procedures were prepared.

Thick film processes optimized for production included silkscreen printing, solder reflow, ultrasonic cleaning, and wire bonding. One prototype switch and 20 engineering sample switches were fabricated.

Technical difficulties in the engineering samples discovered during early testing made it evident that significant mechanical redesign would be required before the SSPS could be mass produced. In the interim, complimentary metal oxide semiconductor (CMOS) technology advancements caused this device to become technically obsolete. The contract was terminated for mutual benefit.

BENEFITS

No direct benefits can be attributed to this project because the solid state power switch was not successfully fabricated.

IMPLEMENTATION

Due to inability to achieve stated objectives, this project was not implemented.

MORE INFORMATION

Additional information may be obtained from Mr. Frederick Perkins, US Army Mobility Equipment R&D Command, Ft. Belvoir, VA, AUTOVON 354-5724 or Commercial (703) 664-5724. The contract number was DAAK70-78-C-0131.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **H80 3012** titled **"Infrared Source for AN/ALQ-144"** was terminated by the US Army Electronics Research and Development Command in January 1983 at a cost of $360,000.

BACKGROUND

The AN/ALQ-144 is a fielded countermeasures set for both Army and Marine rotory-wing aircraft. The infrared (IR) source for the set consists of a chemical vapor deposited (CVD) boron nitride radiating surface heated by a graphite heating element in a hermetically sealed sapphire envelope. When this project began, the fabrication methods involved a large amount of hand labor. Marginal yields were experienced in machining and coating the graphite heater elements. This IR source was the result of three years of selective emitter R&D by ILC Technology and Sanders Associates. The fabrication methods used were not suitable for production.

SUMMARY

The objective of this project was to improve the manufacturing methods to ensure an economical production of the infrared source for the counter measures set. The IR source is shown in Figure 1.

One of the major problems was machining thin walled graphite cylinders from solid stock. The cylinders are 5mm in diameter and 117mm long. Because of this large length to diameter ratio, it is difficult to maintain the constant wall thickness. This problem was addressed by improving the reproducibility of "gun-barrel" drilling and optimizing non-sensor machining in a dedicated graphite heater machining facility. Real-time resistance measurement during machining improved the yield. The improved machining eliminated the requirement for the high labor content oxidation resistance trimming of the graphite heater. Over 200 heaters were machined with an 85% yield.

Another major problem was maintaining the uniform thickness and composition of the chemical vapor deposited boron nitride emitter coating. To resolve this, five coating runs were made at Union Carbide to establish the process parameters for a 9 ± 3 mil thickness. Coating thickness as a function of position in the coating chamber was mapped and the flow rates were determined to maximize the yield. Heater mounting fixtures were designed and built to streamline the CVD set-up. The proper graphite was selected to minimize stress in the coating.

All of the test facilities for this project were completed. The burn-in station and life test station contained microprocessors to cycle five sources through test voltage sequences. A heater check-out station was constructed which was used to run the elements at full power prior to assembly into envelopes. The cross-correlation of the radiation tests of the contractor and ERADCOM was within 8%.

In early 1982, funds to generate an ECP to implement the improved IR source in the Blackhawk and Cobra helicopters were provided by the respective Program Managers. At the same time, the systems contractor offered an improved IR source to the Government as part of the second production contract for the AN/ALQ-144 countermeasures set at no development cost. The Government accepted the offer and cancelled the ECP. ILC Technology submitted a request for termination because there was no possibility of becoming a qualified source. The contract was terminated.

Figure 1 - Infrared Source

BENEFITS

Economical, high-yield production processes were developed for the production of infrared sources for the AN/ALQ-144.

IMPLEMENTATION

These processes were not used in the second production contract. The systems contractor provided the IR source as part of the countermeasure set.

Quotes for spares and future production contracts show the quote from ILC Technology is the lowest. This is believed to be a direct result of the MMT project. Because of the thousands of IR sources involved, a unit cost savings would result in a tremendous total cost savings.

It has been directed that the ILC Technology IR sources be incorporated as part of a modification program which may result in a retrofit of fielded systems.

MORE INFORMATION

Additional information may be obtained by contacting Dr. Joseph O'Connell, USAET&DL, ERADCOM, AUTOVON 996-5407 or Commercial (201) 544-5407. No technical report is available.

Summary report, Dec 83, was prepared by D. Richardson, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **H79 3516** titled **"MMT - Cooler Motor Hybrid Circuit"** was completed by the US Army Electronics Research and Development Command in June 1982 at a cost of $176,000.

BACKGROUND

The purpose of this MMT effort was to develop more economical techniques for producing a motor drive hybrid circuit used in small split-cycle Sterling cryogenic coolers. The hybrid circuit was fabricated using thick-film technology with printed resistors and non-cased semiconductor chips bonded to a ceramic substrate. This circuit is shown in Figure 1. Goals were to attain a 40 circuit a week production capability based on a standard 8 hour shift, and to achieve a 40 percent unit cost reduction.

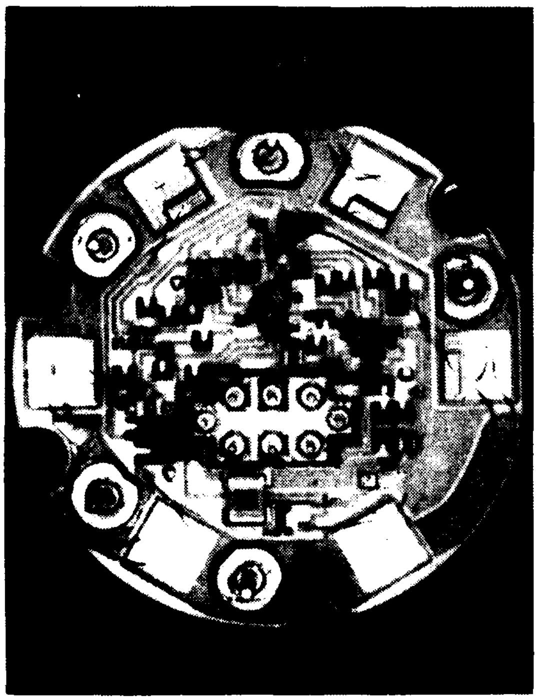


Figure 1 - Motor Drive Hybrid Circuit

SUMMARY

Aeroflex Laboratories at Plainview, New York, was awarded the contract for motor drive hybrid circuit improvements. Tasks selected for potential cost savings were the following:

1. Develop automatic wire bonding techniques to replace manual methods.
2. Replace several transistors with one custom monolithic IC array.
3. Substitute silver for gold used in conductor material.
4. Improve substrate attachment.
5. Optimize pin swaging and soldering.
6. Design a hybrid cover for the current uncased circuit.

The results of the technical investigations are summarized below:

1. A computer controlled automatic wire bonder was purchased that produced more than 20,000 bonds per day. This was greater than 10 times the number of bonds made manually. Initial software deficiencies and 2 axis control problems were corrected and the equipment was incorporated into the production line.

2. The custom chip array was not produced. The automatic wire bonder reduced die and wire bond labor costs sufficiently to render the custom chip array cost ineffective. Since cost savings were the driving factor, the custom chip option was rejected.

3. Gold conductor paths were not replaced with silver. During the course of the project, a gradual reduction in the commercial price for gold shifted the balance in favor of reliability over cost.

4. An epoxy preform with die-punched pen cutouts was devised for bonding the hybrid circuit to an aluminum mounting plate. An assembly jig with clamps was designed to retain orientation and assure correct solder flow during the temperature cure.

5. Swaging fixtures and solder preforms were constructed to assure proper pin swaging to the substrate and proper electrical connection. Added process control precluded substrate cracks and gold leach during solder reflow.

6. A protective G10 material fiberglass cover was designed to protect the hybrid during installation into the motor assembly. The cover was bonded to the ceramic base with standoffs.

Processing and inspection documentation was generated for both confirmatory samples and pilot run. These included substrate and fabrication inspection procedures for wire bonding, die bonding and solder assembly. Twenty confirmatory samples and 60 pilot lot samples were successfully produced.

As a result of this effort, a production capability of 400 circuits/month was achieved.

BENEFITS

This project succeeded in developing the manufacturing technology necessary to fabricate DC motor drive hybrid circuits at a higher production rate. At the start of 1982, production averaged 400 circuits a month. Selling price was reduced from $550/unit to $150/unit.

IMPLEMENTATION

The project results were directly implemented into the production line/split-cycle Sterling cryogenic coolers at Aeroflex. The coolers are used for many night vision devices such as FLIR, AN/TAS-4, AN/TAS-6, FES, and LASER Rangefinder.

MORE INFORMATION

Additional information may be obtained from Dr. Stu Horn, NV&EOL, Ft. Belvoir, VA, AUTOVON 354-1345 or Commercial (703) 664-1345.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **H80 9588** titled **"Third Generation Low Cost Image Intensifier Tubes"** was completed by the US Army Electronics Research and Development Command in July 1983 at a cost of $900,000.

BACKGROUND

Third Generation Low Cost Image Intensifier Tubes are a significant improvement scheduled for Low Cost Night Vision Goggles (LCNVG), AN/PVS-7 and other night vision devices. These tubes are expensive as produced in engineering development. Production techniques and quality procedures were required for cathode liquid phase epitaxial (LPE) growth, microchannel plate (MCP) filming, phosphor screen construction, tube body preparation, and test equipment requirements.

SUMMARY

This project's objective was to establish a manufacturing capability for Third Generation 18mm image intensifier tubes. Work was performed by Varo Incorporated, Garland, Texas.

Tube cross section is shown in Figure 1. It is built with a high sensitivity GaAs photocathode bonded to a type 7056 glass faceplate and utilizes a filmed ion barrier microchannel plate.

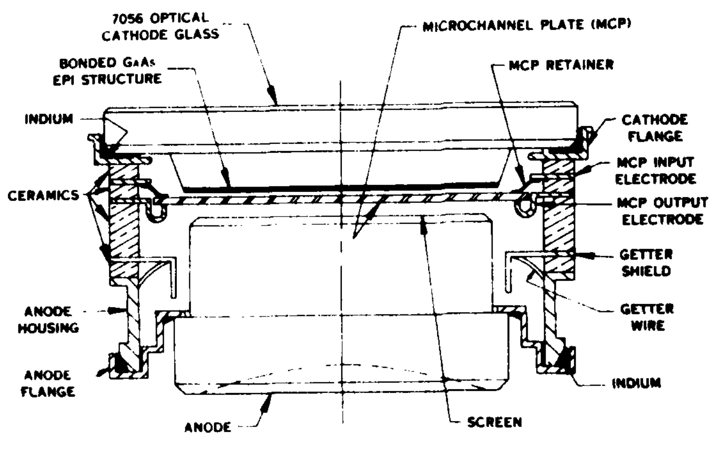


Figure 1 - Cross Section of MX-10130(AN/PVS-7) Tube

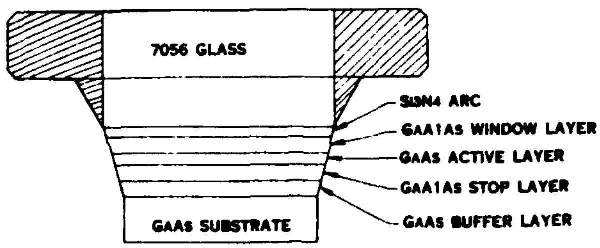


Figure 2 - Bonded Structure With GaAs Substrate Intact

The photocathode consists of alternating AlGaAs and zinc doped GaAs layers epitaxial grown onto a single crystal GaAs substrate. Figure 2 shows the photocathode bonded to the 7056 glass faceplate. An RF sputtered silicon nitride (Si_3N_4) antireflective (AR) coating is on the cathode input surface.

Major contract tasks were the following:

(1) Improve the photocathode LPE growth processes.

(2) Optimize bonding techniques for sealing the photocathode structure to the glass faceplate.

(3) Develop silicon nitride/silicon dioxide anti-reflection coatings.

(4) Establish an ion barrier MCP filming process.

(5) Fabricate improved wafer tube bodies and screens.

The technology was demonstrated by fabricating the tube with specification photocathode sensitivity. These devices met stability requirements when subjected to high light levels and high temperatures. Technical achievements are summarized below:

(1) LPE growth processes were developed to the specification level required for quality cathode production (18 specification cathodes/week). Saturation methods, temperature sequences, temperature profiles, and gas flow rates were optimized.

(2) Photocathode/glass faceplate thermocompression bonding techniques were refined to the 97 percent yield level with five cathodes per hour capacity.

(3) A new mass flow controlled RF sputtering system produced more predictable silicon nitride/silicon dioxide AR coating thicknesses from run to run. A 10 substrate/run/hour capacity was attained.

(4) A MCP lacquer-electron beam film deposition process that produced cosmetically superior Al_2O_3, SiO_2, or SiO films with lower penetration voltages was achieved.

(5) Modifications to the tube phosphor screen included a cold seal indium filled flange and a straight-through (non-twisted) fiber optic. Increased getter shielding and improved getter placement techniques were developed.

Total cathode yield was increased from four percent to slightly over thirty percent in terms of pinhole and thickness uniformity requirements.

Several powerful analytical tools were modified to support the MMT effort. A Scanning Electron Microscope (SEM) was used for examining etching defects in photocathodes, films or MCP's and measuring epitaxial growth layer thickness. The SEM determined inclusion composition in expitaxial growths.

A Scanning Auger Microprobe (SAM) was developed for photocathode examination. It incorporated an Auger spectrometer, its associated electronics, and a sputter ion gun in a specially constructed vacuum system. This SAM permitted removal of a cathode from a finished tube in vacuum. The Auger was also used to determine effectiveness of various cathode cleaning techniques and to detect contamination on ready-to-activate cathodes.

BENEFITS

This effort established and verified processes, procedures, and techniques that will result in lower manufacturing costs for Third Generation image intensifier tubes.

IMPLEMENTATION

This project's results have been documented and are available for use in the AN/PVS-7 night vision goggles when they commence production.

Improved Third Generation image intensifier tubes have been provided upon request to several tube manufacturers for evaluation and comparison purposes.

MORE INFORMATION

Additional information may be obtained from Mr. Ray Stefanik, Night Vision and Electro-optics Laboratory, Ft. Belvoir, VA, AUTOVON 354-1725 or Commercial (703) 664-1725. The contract was DAAK70-80-C-0181.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **H78,81 9889 Task A** titled "**18MM Third Generation Wafer Intensifier Tube**" was completed by the US Army Electronics Research and Development Command in June 1983 at a cost of $971,000.

BACKGROUND

Third Generation image intensifier tubes are comprised of GaAs photocathode, funneled and Al_2O_3 low noise microchannel plate (MCP), and fiber optic phosphor screen. See Figure 1. These tubes provide a smaller size, lighter weight design, greater tube resolution and higher tube gain.

New automated batch processing techniques were needed for tube exhaust, MCP electron scrub, cathode cleaning and activation, and final image tube seal.

This project is Task A of a two task effort to provide more than one source for Third Generation image intensifier tubes.

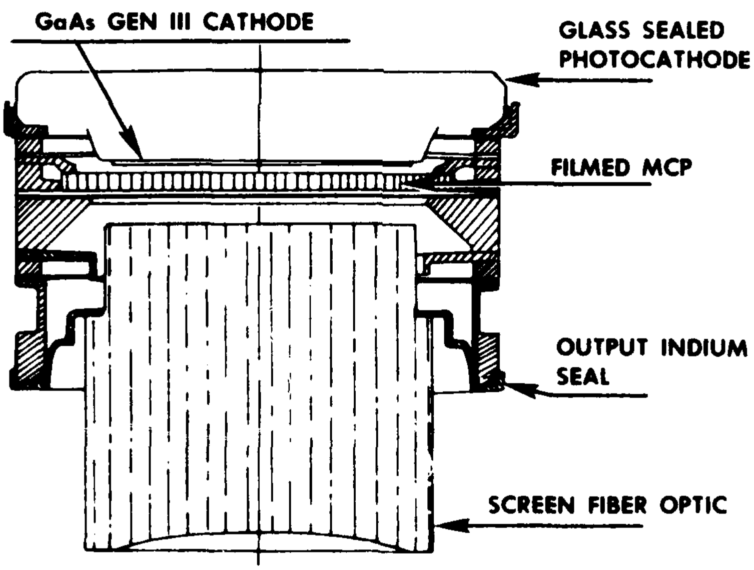


Figure 1 - Generation III Image Intensifier Tube

SUMMARY

Task A was contracted to ITT Corporation at Roanoke, VA. They devised the multiple chamber stainless steel vacuum bell jar structure shown in Figure 2 for automated tube exhaust processing. The construction featured loading through a vacuum interlock and double manipulator arms for docking the cathode into the heat clean fixture and process well. Tubes once sealed can be removed individually from the system. This feature allowed one system bake to outgas 12 tubes simultaneously, thereby, eliminating excessive process time.

Tube processes integrated with the Figure 2 exhaust system include MCP and phosphor screen electron scrub, fiber optic screen getter flash and tube cold indium seal.

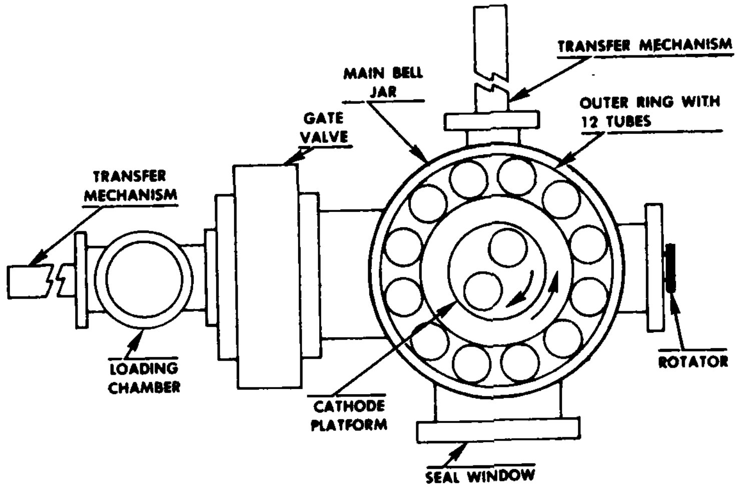


Figure 2 - Twelve Tube Manifold

Photocathode activation was accomplished by applying cesium and oxygen to form a CsO monolayer at the GaAs cathode surface. Post exhaust processes included cathode thermal aging to stabilize photoresponse.

Halo effect was reduced by minimizing the cathode-to-MCP spacing. Veiling glare was lessened by substituting a saturn faceplate with black outer perimeter, for the Bull's Eye faceplate. The new faceplate became a piece part for production.

Electrical tests included photocathode sensitivity (uA/lm), ion-barrier film quality, equivalent brightness input (lm/cm^2), luminance gain, photocathode, MCP and screen quality, center resolution, signal-to-noise ratio and 50 hour burn-in.

Sixteen tubes were utilized to demonstrate operational life under standard reliability conditions. Eight tubes were placed on standard 2000 hour life test and eight tubes on 400 hour accelerated life test. All tubes easily met the required reliability specifications.

BENEFITS

This task successfully established exhaust procedures and a production capability for Third Generation image intensifier tubes.

IMPLEMENTATION

Results of this effort were directly implemented into the ANVIS production at ITT. Total Army ANVIS requirements are anticipated to be 15,000 devices.

MORE INFORMATION

Additional information may be obtained from Mr. William Markey, Night Vision and Electro-Optics Laboratory, Ft. Belvoir, VA, AUTOVON 354-1725 or Commercial (703) 664-1725. The contract was DAAB07-78-C-4970.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **R80 1024** titled **"MMT - Radio-Frequency Stripline Hybrid Components"** was completed by the US Army Missile Command in June 1982 at a cost of $745,000.

BACKGROUND

While design layout methods for stripline circuitry are well established, there are few process guidelines for their manufacture. Production techniques for applying RF circuitry and ground planes and for determining optimum component joining methods were needed.

SUMMARY

Hughes Aircraft Company, Electron Dynamics Division, established low-cost production processes for stripline hybrid (PLANAR) devices in the 94-140 GHz range. The approach used was to adapt semiadditive printed circuit board fabrication methods to selected stripline substrate materials. Techniques for measuring the substrate/channel combination dielectric constant ("K" value) and then altering the substrate and/or its channel to achieve a uniform predetermined "K" value were developed.

Goals were to demonstrate the technology by fabricating 140 GHz output frequency doublers with reproducible efficiency.

Four dielectric materials which showed promise for inexpensive low-loss planar circuitry in 94 GHz to 140 GHz frequency range were investigated. These were RT/DUROID 5880, RT/DUROID 5890, CUFLON and fused quartz.

It was determined that the optimum combination of dielectric and metallic channel for forming a suspended-substrate transmission line is CUFLON or RT/DUROID 5880 in an aluminum or brass channel. This combination minimized transmission line characteristic impedance and dielectric constant change with temperature.

A Hughes developed computer program was utilized to calculate the suspended-substrate transmission line characteristic impedance, dielectric constant, and propagation velocity. Program inputs were channel dimensions, board spacing from upper and lower channel walls, substrate dielectric constant and dielectric thickness. The cross-bar structure selected for the doubler is shown in Figure 1. A metal-clad dielectric substrate board (.005 inch thick CUFLON) extends across the output waveguide. Two diodes bonded to the board, across the center of the waveguide, radiate the doubled frequency directly into the output waveguide. The diodes are coupled to the input waveguide through the suspended substrate transmission line. This planar circuitry is housed in the split block housing shown in Figure 2.

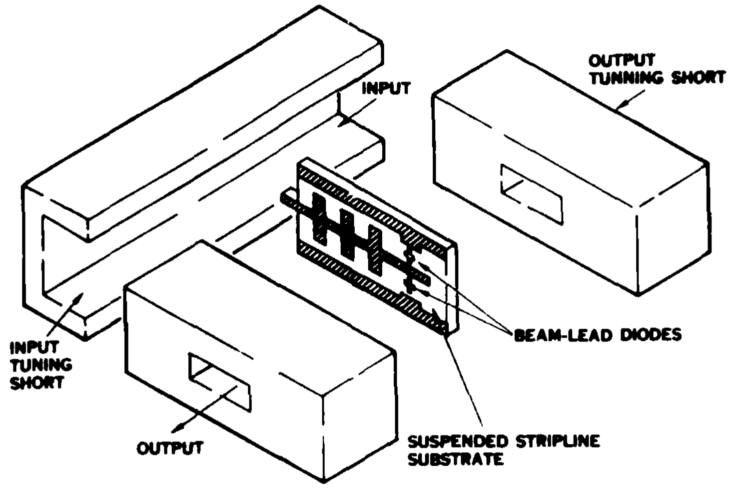


Figure 1 - Diagram of Planar Frequency Doubler

Figure 2 - 70 GHz to 140 GHz Doubler Housing

The Hughes designed beamlead varactor diodes (see Figure 3) are nonlinear elements that generate harmonics of the input frequency. They are matched both to the source and the load.

Manufacturing processes which were optimized include precision rubylith cutting, stripline etching, and reflow-solder beamlead diode attachment.

The Hughes doubler achieved an output power of +9.0 dBm (7.9 mW) at 138.4 GHz with an input power level of 23.9 dBm at 69.2 GHz for a conversion loss of 14.9 dB.

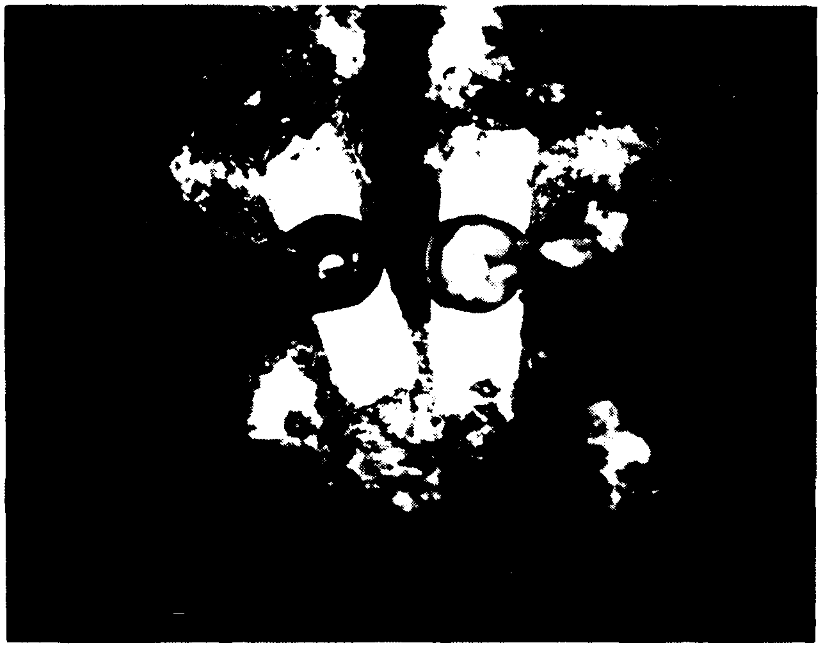


Figure 3 - Beam-lead Varactor Diodes

Multiplier efficiency reproducibility was investigated. Two identical metal clad dielectric circuit boards were fabricated and a different pair of diodes (from the same wafer) were reflow soldered to each board. The boards were tested in the same housing. Test results showed that the conversion loss (efficiency) of each board was within 0.5 dB (12%) of each other.

BENEFITS

This effort has demonstrated a manufacturing capability for planar frequency multipliers. The technology provides a significant monetary reduction over the all-waveguide version. As of this date, an all-waveguide 70 GHz to 140 GHz doubler costs approximately $5,000. A planar doubler at the same frequency would cost approximately $2,000, a savings of $3,000. (Both costs given for manufacturing in quantity.)

IMPLEMENTATION

Similar stripline technology (but not a frequency doubler) is used on the front end switch in WASP at a savings of $1,200 per unit. WASP is an Air Force air-to-surface missile designed by Hughes Aircraft Company. Hughes is producing 1,500 WASP's a month toward a total buy of 40,000 units.

MORE INFORMATION

Additional information may be obtained from Mr. Loyd L. Woodham, US Army Missile Command, AUTOVON 746-8075 or Commercial (205) 876-8075. The contract was DAAH01-81-C-A515.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **R77 3165** and **R78 3165** titled **"Production Techniques for Sealing Hybrids"** were completed by the US Army Missile Command in December 1982 at a cost of $210,000 and $285,000, respectively.

BACKGROUND

Microelectronic hybrid circuits utilized in missile systems today require hermetically sealed metal packages. Present sealing methods which require trial set-up runs and long vacuum bakes for rework are time consuming and costly. In order to eliminate the need for redrying before resealing, a closed loop system was needed so that packages are never exposed to room atmosphere until leak testing is completed

SUMMARY

Several companies collaborated, under MICOM's direction, to produce an integrated in-line production package sealing and testing station. See Figure 1. Goals were a hybrid sealing system with a 100 unit per hour production rate (800 units per 8 hour day) and yields in excess of 95 percent.

The companies and their assigned tasks are listed below:

1. Teledyne-Lewisburg and SCI performed an industry survey in sealing parameters, materials, and equipment.

2. Solid State Equipment Corp. (SSE) designed, fabricated and assembled the "Custom Dry Box System." It consisted of two vacuum bake ovens, vacuum pumps, and cold traps with refrigeration units, two transfer boxes and one parallel seam welding machine.

3. PDC Associates developed the gross leak testing apparatus and level 3 engineering drawing package.

4. M&K Associates produced and installed the fine leak test chamber.

5. Huntsville Microcircuits, Inc. coordinated total system integration and demonstrated system validity. They also prepared documentation and procured the metallic hybrid packages.

Packages were oven baked to remove moisture, hermetically sealed by parallel seam welding, and gross leak tested and returned for rework if required, in a dry nitrogen/helium atmosphere. Hybrids were washed in dry nitrogen to remove excess helium before fine leak testing. Packages were fine leak tested in a dry nitrogen environment by using a "microcircuit fine leak test apparatus" and a helium mass spectrometer.

Hybrid Microcircuit Hermetic Seal and Leak Test System

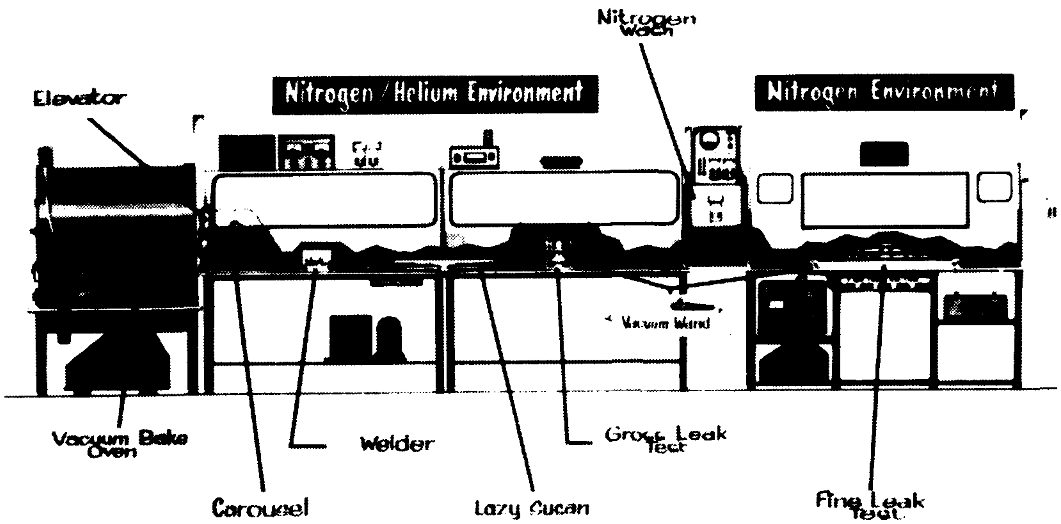


Figure 1 - Hybrid Microcircuit Hermetic Seal and Leak Test System

Approximately 1,000 microcircuit packages and lids were procured. The leak-testing system was brought into operation, packages were sealed and leak-tested, and the operating parameters of the system were documented.

No major errors in system or subsystem design were found, however minor problems were encountered. At the project's conclusion, it was determined that an additional 4 man-months of engineering effort for minor modifications were needed before the system would be fully operational and achieve the 100 package an hour rate, and 95 percent yield, with 99 percent reliability.

BENEFITS

This effort has significantly reduced the cost of microcircuit hybrid packages. Two patents have been awarded, "Pneumatic Gross Leak Detector" and "Microcircuit Fine Leak Test Apparatus."

IMPLEMENTATION

Numerous hybrid circuit manufacturing companies have expressed interest in utilizing the "Hybrid Microcircuit Hermetic Seal and Leak Test System."

Hughes Aircraft Company and Westinghouse Electric Corporation are considering interfacing this system with their microcircuit production line.

MORE INFORMATION

Additional information may be obtained from Mr. Bobby Park, US Army Missile Command, Redstone Arsenal, AL, AUTOVON 746-7057 or Commercial (205) 876-7057.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **R80 3435** titled **"MMT High Power Thick Film Hybrids"** was completed by the US Army Missile Command in December 1982 at a cost of $290,000.

BACKGROUND

One of the major applications of thick-film hybrid circuits today is in low voltage power supply circuits. The key advantage in utilizing thick-film power hybrid circuits for power supplies is the large reduction in power supply weight and volume. This project sought to identify and address selected thick-film power hybrid areas which would enhance producibility and lower fabrication costs.

SUMMARY

Westinghouse, at Baltimore, Maryland, was funded to perform the investigation into processes, equipment for thick film low voltage power hybrids. Major areas studied were the following:

1. Thick film materials.

2. Large diameter wirebonding.

3. Multilayer cost analysis.

4. Resistor laser trim.

5. Automated handling equipment.

6. Thick film microcircuit definition for pilot production, utilizing technology developed in the total effort.

A typical power hybrid is shown in Figure 1. Circuitry was designed such that power functions and logic functions are separated. Power transistors are attached to BeO substrates while logic functions are carried out on 96% Al_2O_3 substrates. The logic substrate contains the passive elements; i.e., conductors, resistors, and dielectrics (insulators).

The material study comprised conductor, resistor, and dielectric paste characterization (viscosity and fired percent solids) and a functional analysis of their printed, dried and fired on substrate properties. The task also included an evaluation of thick film backing layer/solder alloy systems.

Wire bonding concerned the feasibility of bonding heavy aluminum wires to thick film gold, and included a bonding equipment search.

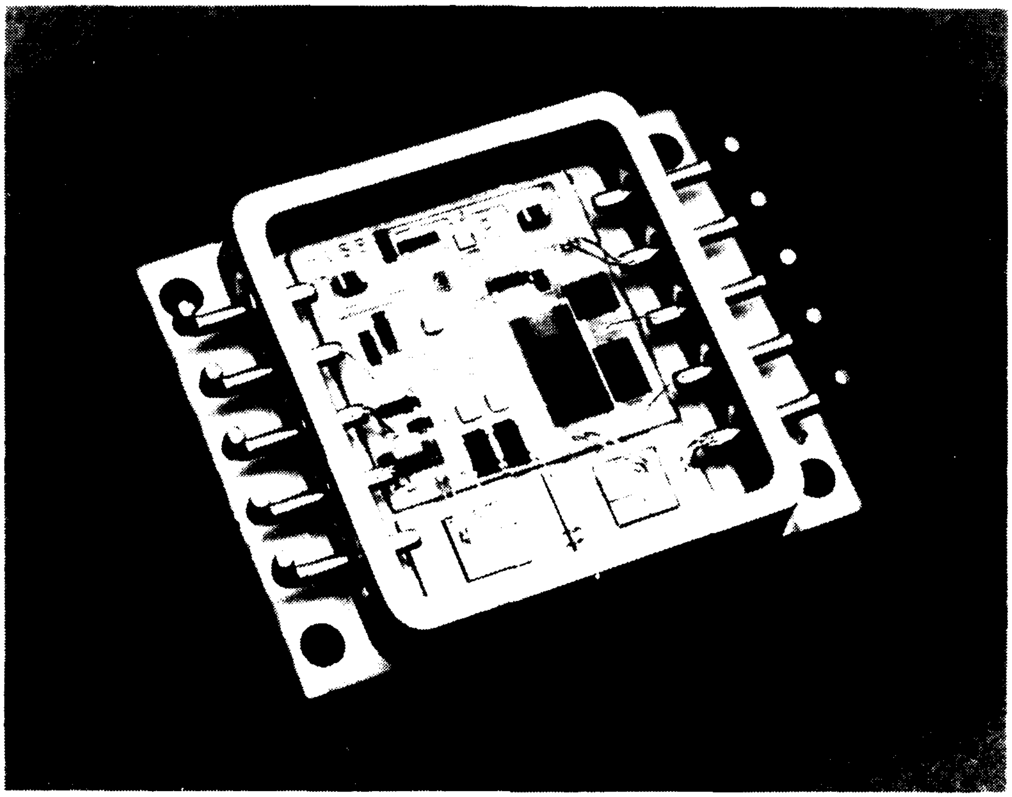


Figure 1 - Power Hybrid

Resistor laser trim included investigation into both static and dynamic trimming. Static trim involved only a laser trimmer system. Dynamic trim contained, in addition to the laser system, the necessary test equipment and interfaces to functionally exercise the assembled power hybrid. This comprised power supplies, dynamic loads, pulse/function generators, DVOM's, and in-house designed interface panels.

A summary of the results achieved are listed below:

1. Established a low cost reworkable backing layer/solder alloy system of DuPont 6160 (Ag)/Sn 62.5 Pb 36.1 Ag 1.4 for substrate to header attachment.

2. Produced the capability for bonding heavy (.020 inch) diameter aluminum wires to gold.

3. Identified and procured a modified heavy aluminum wire bonder (Orthodyne model 20) with a higher level of automation achievable than on existing machines.

4. Derived equations for determining the cost effectiveness of chip resistors vs screened resistors.

5. Identified a screen printable low ohmage resistor system and generated a first order design standard for such resistors.

6. Identified a circuit candidate to utilize the results of this effort.

BENEFITS

Due to this effort's technical achievements, power hybrid fabrication costs have been significantly reduced. The reworkable backing layer/solder system for substrate to header attachment, alone reduced the material costs by 50 percent.

IMPLEMENTATION

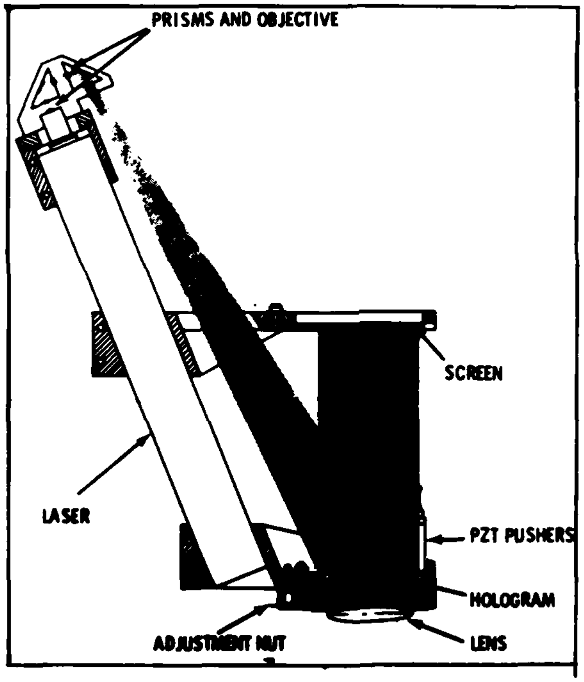
The results of this effort have been incorporated into power hybrids used in many DoD systems, such as TPS-43, 63, 70 radars, ECM, and marine radar.

MORE INFORMATION

Additional information may be obtained from Mr. Loyd L. Woodham, US Army Missile Command, Redstone Arsenal, AL, AUTOVON 746-8075 or Commercial (205) 876-8075. The contract was DAAH01-80-C-1449.

Summary report, Dec 83, was prepared by S. Yedinak, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

INSPECTION AND TEST



OPTICAL HOLOGRAPHIC TEST EQUIPMENT

ABSTRACTS

Project Number	Project Title	Page
677 7714	Multi-Mode Weapon Mount Impedance Simulator	I-5

Traditional methods for production and acceptance testing of automatic weapons do not provide enough flexibility to accurately simulate field conditions. This project developed a prototype One-Degree-of-Freedom weapon mount simulator to duplicate the complex spring rates and damping ratios observed in field use. Data on mounting conditions was collected for various weapons and the weapons were tested. Change in firing rate and accurance were then observed upon simulator recoil. Use of this simulator is expected to result in greater accuracy and annual savings of $105,000.

679 8025	Electronic Profile Readout Gage for Powder Chamber Controls	I-7

The gage testing of the powder chamber of the 8" M201 was previously a time consuming process utilizing individual comparator gages. This project developed a single gaging system composed of an Electronics Control and Data Processing Unit and a Cannon Chamber gage. Sensors measure distances between a central parallel and the gun walls at chamber drawing specification locations. A digital display then indicates these measurements to the operators. Additional systems are being procured for other gun tubes as well.

678 8048	Improved Inspection Techniques for Ingot and Preforms for Rotary Forging	I-9

Conventional nondestructive testing of ingots prior to rotary forging is performed manually using a hand-held transducer. This project developed an automatic NDT system with the capability to perform 100 percent inspection at the rate of three ingots per hour. The system consists of a focused immersiontransducer and pulse-echo ultrasonic equipment. It has the capability to detect 3/64-inch defects in the center of a 20" diameter ingot. This equipment is currently installed at Watervliet Arsenal and has allowed a time savings of 20-25 percent for ingot inspection.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **576 4327** and **577 4327** titled **"Automated X-Ray Inspection System (AXIS)"** were completed by the US Army Armament Research and Development Command in January 1979 at a cost of $260,000.

BACKGROUND

A modern, automated melt-pour system is currently being developed at Lone Star Ammunition Plant for the mass manufacture of HE loaded 105mm M1 projectiles. This system will load a minimum of 1,000,000 projectiles per month or 16,000/shift. A 10% x-ray sampling plan in accordance with MIL-STD-1235A will be used to inspect the projectiles. The current plan is to employ one linatron (4 MEV) x-ray machine to handle this requirement, coupled with automatic film processors to expose the film automatically and use a human observer to make the accept/reject decision. The only problem with this approach is the questionable reliability and repeatability of human radiographic interpreters in high production rate situation. In view of the fact that critical defects in HE artillery shells can cause premature detonations, the requirement to improve upon the present radiographic process is of the utmost importance.

SUMMARY

The purpose of this project was to demonstrate that digital image analysis techniques can be used to solve the problems of automatically interpreting x-rays of 105mm HE projectiles and arriving at a decision either to accept or reject the projectile. The primary objectives of this phase of the program were (1) the development of a conceptual model of the system, (2) the development of conceptual design, and (3) implementation in an operational system.

The program was more difficult than anticipated so the resources were judiciously expended on answering the basic question "can automatic analysis be performed on these x-rays?" In order to answer this basic question, a set of algorithms was developed to locate the defects in the x-ray and decide if the projectile is acceptable. These algorithms were programmed to run on a minicomputer and ultimately demonstrated that x-rays of projectiles can be scanned, digitized, and evaluated to locate defects in the projectiles and either accept or reject them. The system that was used to demonstrate this capability on x-ray film images consisted of an image scanner, five quarter frame memories, a host minicomputer with associated peripherals, three high speed processors and a display, Figure 1.

Also, several other technical aspects were addressed during the development of the algorithms.

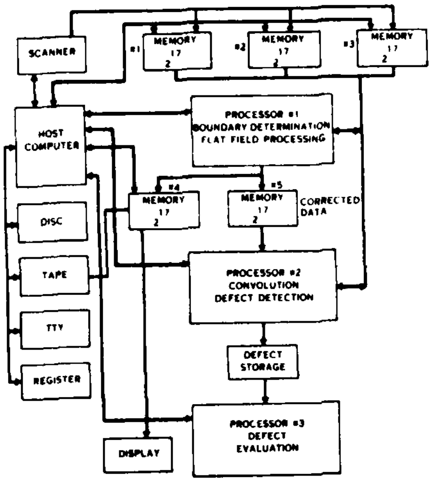


Figure 1 - Defect Detector System

1. Scanner selection.

Three types of scanners were evaluated, a scanning microdensitometer, a flying spot scanner, and a TV camera. The results indicated that a TV camera can be used as a scanner. It still has to be proven that the required contrast sensitivity and dynamic range can be obtained with a TV camera. If the TV camera can be used, then the whole process of scanning becomes greatly simplified.

2. Optimizing algorithms.

To get algorithms to demonstrate the x-ray film reading capability, much parallel programming was performed which necessitated fitting all the programming together. The final operating software works but it is not optimized. As a result the software is far more complicated than required. Some modifications are required along with further testing and evaluation, tuning, and calibration.

3. Implementation.

One of the more perplexing problems facing purchasers of complex systems is deciding which system will cost the least and perform the best. With this in mind, it appeared to be unwise to propose, on a firm basis, equipment for analysis and later attempt to fit the optimized algorithms to the system. The suggested approach was to optimize the algorithms, time them and then, based on the operation cycle time, design an efficient system for implementation.

BENEFITS

The results obtained from this effort successfully demonstrated that digital image analysis techniques can be used to solve the problem of automatically interpreting x-rays of 105mm HE projectiles and arriving at a decision either to accept or reject the projectile.

IMPLEMENTATION

The results of this effort will be used to develop the AXIS production prototype system, MMT Project No. 578 4454-2.

MORE INFORMATION

Additional information concerning this effort may be obtained from Dr. Josepn M. Argento, US Army Armament Research and Development Command, AUTOVON 880-4238 or Commercial (201) 724-4238.

Summary report, Dec 83, was prepared by D. Brim, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **677 7714** titled **"Multi-Mode Weapon Mount Impedance Simulator"** was completed by the US Army Armament, Munitions and Chemical Command in January 1983 at a cost of $360,000.

BACKGROUND

Traditional methods for production and acceptance testing of automatic weapons usually include function firing under a specified condition of gun-mount rigidity. Such tests comprise merely a go/no-go inspection at a single point in the spectrum of field service conditions within which the weapons must reliably operate.

To overcome these deficiencies, a testing procedure is needed that provides more realistic field conditions than are now possible with present weapon mount simulators.

SUMMARY

The objective of this project was to provide the Army with a prototype Second Generation One-Degree-of-Freedom weapon mount simulator capable of simulating the complex spring rates and damping ratios found in the field. A table of representative mounting conditions for weapons from 50 caliber to 30mm was generated. This data included the range of spring rates between the gun, gun mount, and delivery vehicle; and, between the vehicle and ground. In addition, the range of weights for the guns and vehicles was developed.

Using this data a simulator, known as the Second Generation Multi-Mode Weapon Simulator was designed and fabricated. The simulator can respond to gun firing as a two mass, two spring mechanical system duplicating the required spring rates and damping ratios. A picture of the simulator with the M85 Machine Gun mounted on it is provided at Figure 1.

Operation of the simulator is extremely simple. The two spring rates, masses and damping rations for the mount to be simulated are dialed in at a control console. When a mounted weapon is fired, the round impulse causes the simulator table to recoil. A unique model-adaptive control system causes the table motion to duplicate the motion of the programmed mount. Characteristics of the weapon, including change in firing rate, change in accuracy, recoil transmitted to mount, etc., can then be easily measured as a function of mounting conditions.

The simulator contains a series of safety interlocks that automatically stops weapon firing if an unsafe condition occurs.

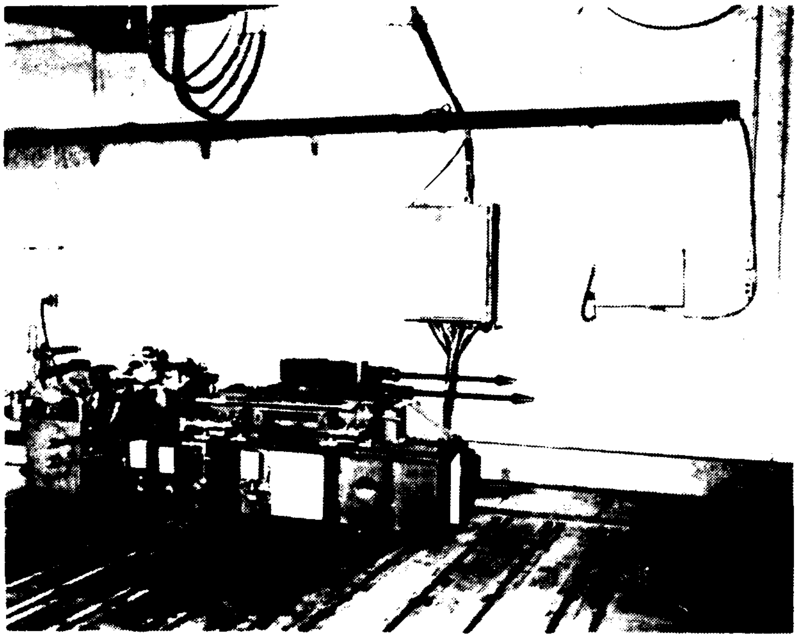


Figure 1 - Multi-Mode Simulator With M-85 Machine Gun

BENEFITS

With this multi-mode simulator, weapons from 50 caliber to 30mm can be tested in a laboratory environment under mounting conditions duplicating those encountered in the field. This provides an inexpensive means for measuring weapon characteristics under more realistic firing conditions than hard stand tests. Annual savings of $105,000 are projected.

IMPLEMENTATION

The simulator is installed and in use at the Keith L. Ware Simulation Center, Rock Island, IL. A technical data package is available for additional procurements.

MORE INFORMATION

Additional information is available from Mr. Robert J. Radkiewicz, US Army Armament, Munitions and Chemical Command, AUTOVON 793-6868 or Commercial (309) 794-6868.

Summary report, Dec 83, was prepared by J. Sullivan, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **679 8025** titled **"Electronic Profile Readout Gage for Powder Chamber Controls"** was completed by the US Army Armament, Munitions and Chemical Command in September 1982 at a cost of $106,000.

BACKGROUND

The powder chamber of a large caliber gun tube is one of the most intricate zones in the barrel design. (See Figure 1). This internal surface must accept and seat the projectile and restrain the pressures created when the propellant is detonated. The interrelated surfaces within the chamber's profile, made up of radii, tapers, and straight zones intersecting, are subjected to tight machining tolerances. Presently a steel flush pin-type gaging system made up of eight individual comparator gages is used to control the final dimensions for the 8" M201. Though dependable, this quality control process is time consuming and leads to operator fatigue.

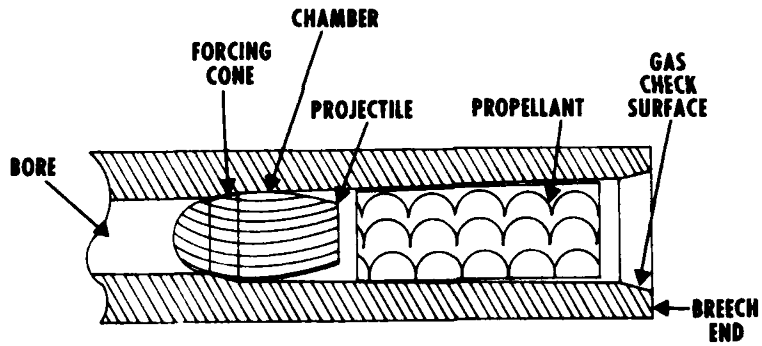


Figure 1 - Powder Chamber

SUMMARY

The objective of this project was to replace the steel comparator flush gages with a single gaging system for the 8" M201 chamber. An industry survey was conducted and desired features for the gaging system were identified. The gage must be: dependable, accurate, wear resistant, relatively light weight, possess an inch/metric scale, and produce a digital visual output signal that could be transformed into a means of machine control at some future point in time.

The industrial analyses led to the development of a detailed specification for an electronic profile readout gage. A contract was negotiated and awarded and a gage was fabricated. The resulting Chamber Electro-Optomechanical Gaging System consists of two units; an Electronics Control and Data Processing Unit and the Cannon Chamber Gage. The Gage Assembly contains master tool steel parallels serving as references, establishing an area where diametrical and taper measurements are made. The gage locates a parallel at each chamber zone measurement location. Two diametrically opposed radial motion sensors measure the radial dimension between the parallel and the chamber side wall. A linear scale senses the on-axis down chamber location of the radial sensors with respect to the chamber entrance face.

The gage system provides a direct data display at chamber drawing specification locations. Both inch and metric readouts are available. Each item on the control panel has some form of indication showing whether or not the system is active and properly set up.

BENEFITS

The Chamber Electro-Optomechanical Gaging System reduces the gaging time by .5 hour per tube. In addition the signal produced by the sensors can be used for future machine controls as well as a printed record for inspection documentation.

IMPLEMENTATION

The gaging system has been accepted by manufacturing and will be used on the next large production run of 8" gun tubes. Additional gaging system based on the technology demonstration under this project are being procured for other gun tubes, (120mm, 155mm, etc.).

MORE INFORMATION

Additional information is available from Mr. Nickolas Dinovo, Watervliet Arsenal, AUTOVON 974-5611 or Commercial (518) 266-5611.

Summary report, Dec 83, was prepared by J. Sullivan, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

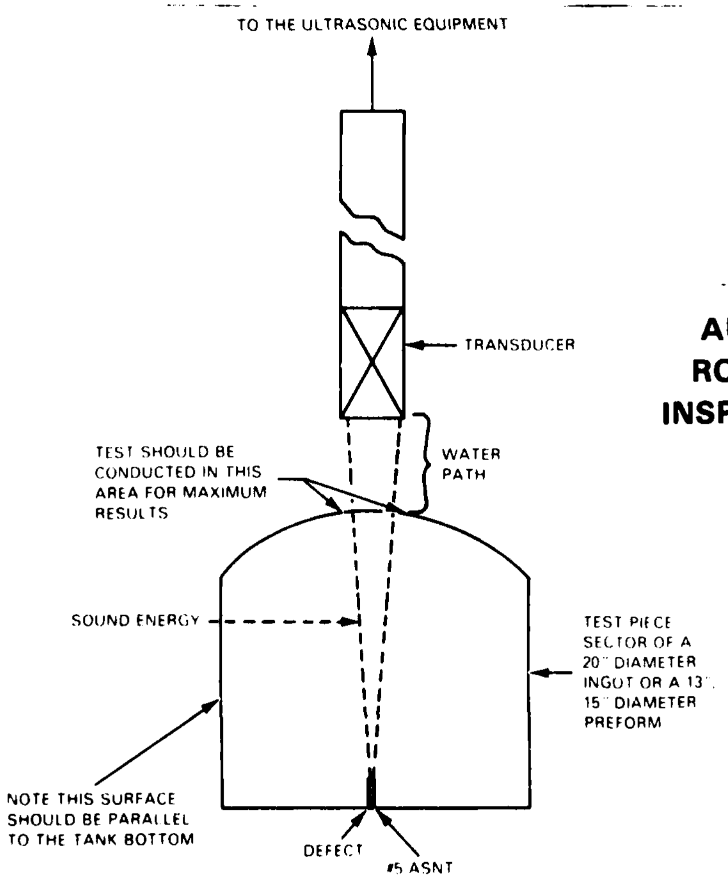
MMT Project **678 8048** titled **"Improved Inspection Techniques for Ingot and Preforms for Rotary Forging"** was completed by the US Army Armament Materiel Readiness Command, Watervliet Arsenal in September 1982 at a cost of $154,000.

BACKGROUND

Before an ingot can be rotary forged, a nondestructive test (NDT) is required to insure the internal soundness. This test was accomplished by ultrasonic scanning using a hand-held transducer, which was very time consuming and prone to operator fatigue and error. Ingot NDT time required often threatened to impede the rotary forging schedule. As a result, in many cases the NDT ingot test was not performed.

SUMMARY

This project was initiated to develop an automatic NDT system to perform 100% inspection of ingots for rotary forging. This project produced an automatic ultrasonic NDT system. Figure 1 depicts the concept.



AUTOMATIC ULTRASONIC ROTARY FORGE PREFORMS INSPECTION SYSTEM CONCEPT

This system has the capability to perform 100% ingot NDT in the rotary forge production line at a rate of 3 units per hour. The ingot sizes, both solid and hollow, tested by this system range from 20" diameter and 8' long to 15" diameter and 11' - 4" long. This is an immersion type system with a focused immersion transducer (2.25 MHZ) (1 x 1/2 resolution) and Pulse-Echo ultrasonic equipment. The energy transfer is accomplished by a couplant-column dispenser/chamber arrangement using water as the sonic transfer medium. The size of defect detected at the center of a 20" diameter ingot under actual conditions was an ASTM number 3 (3/64" diameter) longitudinally oriented flat bottom hole perpendicular to the longitudinal center line. The ultrasonic equipment is a Sperry Model S-80 Reflectoscope. The reflectoscope and the integrated components used detected this size defect exceedingly well. The signal to noise ratio averaged 7 to 1.

BENEFITS

The primary benefit realized by the Army from this project was the capability to automatically nondestructively test all ingots prior to rotary forging. Also, the inspection time should be reduced by 20-25% with a corresponding cost saving.

IMPLEMENTATION

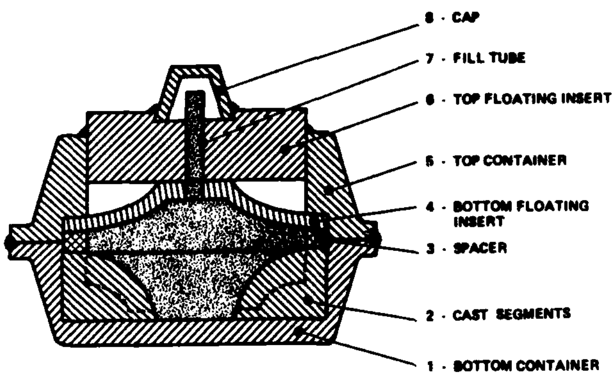
This automatic ultrasonic inspection system has been placed in the rotary forge production line at Watervliet Arsenal, Watervliet, NY.

MORE INFORMATION

To obtain more information, contact project officer, V. J. Colangelo, AUTOVON 974-4201 or Commercial (518) 266-4201.

Summary report, Dec 83, was prepared by D. Brim, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

METALS



DETAIL	MATERIAL SHAPE
1	BAR OR TUBING AND PLATE
2	INVESTMENT CAST SEGMENTS WELDED INTO A RING
3	PLATE OR TUBING
4	PLATE
5	BAR OR TUBING
6	BAR OR PLATE
7	TUBING
8	BAR

FLUID DIE SCHEMATIC AND RESULTING IMPELLER

ABSTRACTS

This project is part of an ongoing effort to reduce the content of non-metallics in superalloy powders. Various clean production techniques were investigated including electron beam melting and bulk powder cleaning. Water elutriation, a technique for determining the size range and quantity of non-metallic inclusion particles, was also refined.

Recent increases in torsion bar stress specifications require higher strength bar materials. Current Bradley torsion bars are composed of 300M steel, a costly specialty steel which provides high strength and fracture toughness. This project investigated various alternatives to 300M steel, finally selecting 4350 Aircraft Quality steel. One-third length test specimens exhibited an average life which exceeded specifications by 84 percent. The proposed 4350 steel is approximately one-third the cost of 300M steel and will be recommended as a direct replacement following additional delay.

Lathe spindle speeds of 400 to 500 revolutions per minute are typical when manufacturing artillery shells. This project attempted to analyze metal removal rates well in excess of these typical figures. Tests were run on a 250 hp lathe, using two materials and five cutting tools. Several conclusions and recommendations were made and compiled into a technical report, including the use of ceramic cutting tools for heat treated shells, variable spindle speed control and feed control.

Page

673 7340	MMT Determination and Certification of an "In House" Armor Steel Casting Process	ME-26

Difficulties in obtaining armor steel castings result from the small quantities required and long vendor lead times. This project alleviated the problem by designing a production process and obtaining in-house certification for casting at Rock Island Arsenal. Chemistry, casting processes, heat treatment and quenching processes were investigated and the test blocks produced were required to pass ballistic, impact and radiographic tests. Castings for the rotor, plate, door, and cover of the M127 Gun Mount are currently being produced using this in-house process.

677 7485	Application of Chemical Processes to Improve Surface Finish	ME-28

Traditional metal removal operations such as honing, grinding and deburring of gun tubes require a significant amount of time. Plating problems are caused by the necessary bore cleaning to remove machined chips. Electropolishing tests were conducted with various initial surface finishes to determine satisfactory finishing characteristics. The resulting polishing system has plating as well as polishing capability, eliminates organic and oxidation contaminants, burrs, and surface imperfections associated with mechanical processes and yields projected annual savings of $60,000.

677 7652	Application of Coolant Chip Ejector Tooling	ME-30

This project evaluated and applied coolant chip ejector tooling to the machining of cylindrical weapons components in an attempt to eliminate multiple operations, reduce scrap and improve quality. Various carbide indexable insert oil hole drills were investigated and criteria was established to provide for comparative analysis of tool life, penetration rate and cost. The use of coolant chip ejector counterboring on M198 Recoil Cylinders resulted in a 22 hour per cylinder reduction in machining time and expected annual savings of $450,000.

		Page
680 7920	Conservation of Critical Material for Gun Tubes	ME-32

Chromium imparts hardenability, temperability, general corrosion resistance, and secondary hardening to steels. It is also expensive and available primarily from foreign sources. This effort experimented with the levels of molybdenum and manganese in order to produce lower-chromium steel having properties similar to gunsteel. An acceptable composition was determined showing no length variability, acceptable hardenability and a $.05 to $.10 savings per pound.

679 7948 680 7948 681 7948	Establish Cutting Fluid Control System	ME-38

Cutting fluids used by Rock Island Arsenal have historically been procured by trial and error; if a fluid performed satisfactorily on a given machine, it was reordered for use with that machine. This effort established a cutting fluid control system which includes fluid selection, stocking, distribution, testing, application, maintenance, and disposal. Processes studied included grinding, milling, burning, boring, and drilling and tested such variables as machine feeds and speeds, tooling, depth of cut, and material. The resulting recommendations were implemented at an annual savings of $25,000 with potential annual savings of $600,000 to $1,200,000.

R80 1018	Improved Manufacturing Processes for Dry Tuned Accelerometers	ME-58

This project developed the necessary technology to apply electrical discharge machining (EDM) to the production of a new design for a two-axis, dry tuned accelerometer suspension. Machining parameters, including machine settings, dielectric fluid, and electrode material and geometry, were optimized and quality assurance techniques determined. This new process resulted in a reduction in suspension cost from $650 to $180 each.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **177 7197, 179 7197, 180 7197** and **181 7197** titled **"Fabrication of Integral Rotors by Joining"** were completed by the US Army Aviation Research and Development Command in February 1983 at costs of 300,000, $100,000, $100,000 and $190,000, respectively.

BACKGROUND

Current gas turbine rotor fabrication is limited to either: (1) integrally cast rotor which has limited experience and does not permit obtaining optimum mechanical properties in both the blade and disk or, (2) the separate blade and disk attachment which required complex and expensive machining of both the blade and disk and creates a potential life problem due to stress concentrations that arise. The use of bonded blade and disk permits the separate generation of optimum mechanical properties in the blade and disk and eliminates the expensive machining required for mechanical attachments. The capability to inspect and repair/replace damaged parts has been demonstrated by the gas turbine industry. The advantages include low cost, lower stressed parts, and reduced machining.

SUMMARY

The objective of this program was to develop manufacturing processes for the production of cost-effective dual-property turbine wheels applicable to any small turbine engine system. Four approaches investigated were as follows:

1. Metallurgical bond, one step, with P/M hub consisted of cast blades ground and tack welded into a blade ring. The blade ring and the hub powder were encased in split ceramic molds and HIP compacted. Figure 1 shows the exploded assembly after HIP.

2. Metallurgical bond, two steps, with P/M hub consisted of a cast alloy blade ring. The ring and hub powder were HIP in two steps to form a complete turbine wheel.

3. Mechanical bond, one step, consisted of a P/M hub machined to accept slotted single crystal doublet blades which are pin connected to the hub.

4. Bi-cast mechanically bonded process consisted of making individual blades under controlled conditions optimized for their configuration and service requirements. The blades were then inserted into a ceramic mold. The hub section was around the blades making a mechanical bond with the blades eliminating the root machining and assembly operation. The blades were inspected before being placed in the hub component mold thereby eliminating wheel scrap resulting from defective blades.

Figure 1 - Top View of "As-HIP" Consolidated Wheel Assemblies

The pilot production of the rotors was successfully completed and the rotors were machined for spin test and engine testing in the follow-on year.

A detailed economic analyses of the entire production processes and processing specifications will be prepared for engine-ready hardware in the follow-on year of this project.

BENEFITS

Anticipated benefits upon completion of the program will be a bonding technique to join dissimilar materials. Other benefits will be overall reduction in parts and machining permitting significant reduction in the cost and longer life rotors for T63 A700/A720 engines in the OH58 helicopter.

IMPLEMENTATION

Upon completion of the overall project, the manufacturing process developed will be coordinated with various project managers and other cognizant Army activities to implement qualification/certification of a turbine rotor fabricated by joining dissimilar materials. Also, the process developed will be coordinated through Army maintenance for incorporation into modernized T63 engines for OH58 helicopters.

MORE INFORMATION

Additional information covering this project may be obtained from Mr. J. M. Lane, Applied Technology Laboratory, US Army Research and Technology Laboratories (AVRADCOM) AV 927-2771 or Commercial (804) 878-2771.

Summary Report, Dec 83, was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **178 7286, 179 7286,** and **180 7286** titled **"High Quality Superalloy Powder Production for Turbine Components"** were completed by the US Army Aviation R&D Command in January 1983 at a cost of $576,000.

BACKGROUND

A problem occurred with obtaining superalloy powder cleanliness during an earlier MMT project titled "Development of Hot Isostatically Pressed Rene 95 Turbine Parts." Current processes used to make superalloy powders produce a powder which has a relatively high content of non-metallics. To overcome this problem, powders are screened which results in a high rejection rate.

By reducing the level of non-metallic inclusions and thermally-induced porosity (TIP), the yield of useful powder from the powder manufacturing process will be increased and higher design strength limits for many alloys will be permitted. These projects will investigate how impurities are introduced into the powder at all stages in the process, beginning with ingot melting.

This MMT effort is a joint service investigation, funded by both Army and Air Force, under contract with Pratt & Whitney Aircraft and General Electric Company. A follow-on project, 182 7286, will continue the investigative effort to identify sources of inclusions and reduce/eliminate the impurities at the source.

SUMMARY

The overall objective of the four-year effort is to improve superalloy powder metallurgy (PM) by minimizing the introduction of inclusions at the source. Reducing the frequency or eliminating inclusions which form premature low-cycle fatigue (LCF) initiation sites in a compacted shape would lower the quality control testing costs and reduce overall life cycle costs; i.e., achieve longer life for aircraft gas turbine PM superalloy disk components.

One phase of the overall effort investigated the production melting practice for advanced superalloys that would yield "clean" ingot material for subsequent powder production. Specific goals under this program were to reduce total oxide content to 0.2 ppm (parts per million) and to reduce maximum oxide size to 1.0 mil. To date, it has been shown that double electron beam melting produced ingot material consistently below the 0.2 ppm goal and reduced the average oxide particle size to approximately 0.7 mils.

During the investigation of this phase, several shortcomings were identified in the electron beam melting process. Some of the shortcomings were suspected to contribute to higher levels of non-metallic inclusions in the remelted ingot. Specific items, which have yet to be investigated, are as follows: non-turbulent ingot feed, hearth and ingot oxide raft removal, double skimmer dam melting, vertical dam positioning, and reduced vacuum level melting.

Concurrent investigations were being conducted on the powder manufacturing processes beyond the ingot stage. Phase I evaluations of Rene 95 master powder blends (MPB's) demonstrated that powder cleanliness and LCF properties were improvable via detailed investigations of the inclusion types and sources and subsequent elimination of those sources. However, cleanliness levels in the range considered necessary for consistently achieving the desired LCF properties were not actually achieved by either of these production sources. Bulk powder cleaning processes were also evaluated but none of the processes evaluated demonstrated a sufficient overall powder cleanliness improvement which would be sufficiently reliable for Rene 95 PM production cleanup.

Inspections and tests performed on loose powder included metallography, SEM (Scanning Electron Miscroscope) analysis, apparent/tap density, chemistry, and water elutriation. Water elutriation is a relatively new technique and played a major role in determining size range and quantity of inclusion particles in powder. The water elutriation inspection procedure, which separates inclusions from metal powder based on density differences, was developed at General Electric. A fluidized bed is created in the elutriation tube as shown in Figure 1 and causes light nonmetallic particles (ceramics, organics) to rise and become entrained in the water column. The low density particles are washed out of the elutriator tube and collected on a filter. Following separation, the particles are examined under the stereomicroscope for classification by visual/touch (tweezers) classification. Based on this effort, the water elutriation test is one of the better loose powder inspection technique for use as in-process cleanliness evaluation test.

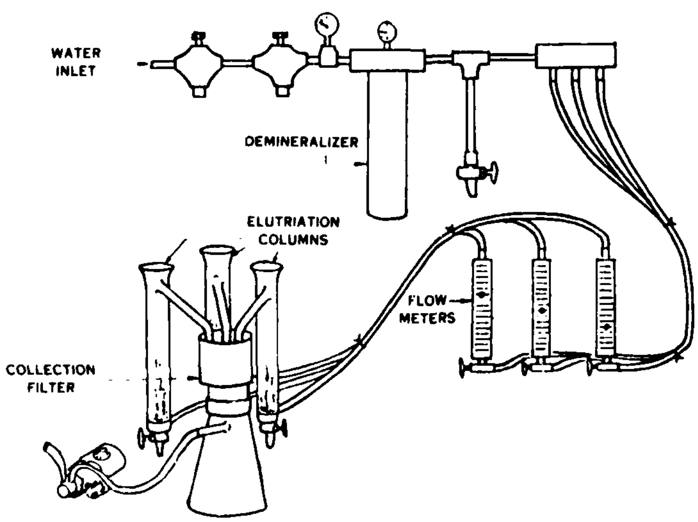


Figure 1 - Water Elutriation

Seeded compact evaluations in Phase II revealed that some organic materials and some ceramic materials can cause large prior particle boundary decoration inclusions in PM Rene 95 by reaction with elements at the nearby powder particle surfaces during heating for HIP compaction.

The combined Phases I and II results indicated that further efforts were required to minimize or eliminate the detrimental effects to LCF properties of the two major inclusion types: reactive inclusions and discrete ceramic inclusions.

BENEFITS

These projects, in addition to the follow-on Project 182 7286, will establish manufacturing procedures for producing cleaner, high quality superalloy powders to be used in the manufacture of gas turbine engine components. A benefit gained from the work to date is the refinement and continued use of the water elutriation technique for determining size range and quantity of inclusion particles in powder. Several improvements in the powder manufacturing process have also taken place as a result of the determination of the process step where inclusions were introduced. Filters have been installed in the Argon system which have effectively eliminated the Argon supply as a source of significant contaminants. In addition, several proprietary modifications to the powder manufacturing process have been made that have improved the quality of the powder. These improvements are evidence of a much greater awareness by both powder producers and users of maintaining a clean environment in processing superalloy powders.

IMPLEMENTATION

As noted above, several improvements have been implemented in the powder manufacturing process as the sources of inclusions have been detected. Total implementation of this multi-year effort awaits completion of the follow-on 1982 project.

MORE INFORMATION

Additional information on this project is available from Mr. Saul Isserow, US Army Materials and Mechanics Research Center, AUTOVON 955-3504 or Commercial (617) 923-3504.

Summary report, Dec 83, was prepared by J. Bruen, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **479 4586** titled "**MMT Improved Large Armor Castings (Phase I)**" was completed by the US Army Tank Automotive Command in February 1982 at a cost of $663,000.

BACKGROUND

The Army currently uses large quantities of steel castings in the construction of heavy combat vehicles. The M60 Tank consists primarily of cast armor, turret and hull representing a major portion of the total vehicle weight. The M1 Tank, while primarily consisting of rolled armor fabrication, requires a significant amount of steel castings and components. Limited prior work has shown that the cast product can be improved with current state-of-the art methods. This effort was planned to demonstrate the feasibility of improved armor castings through casting of large test plates and structures and their improved ballistic capability.

SUMMARY

The objective of this project was to produce a cast armor simulated section casting with ballistic properties approximately the same as rolled homogeneous armor. Plates 48-inch by 60-inch by 5-inch were used to determine the casting process necessary to provide the improved ballistic performance.

A study was performed to determine the influence of various production methods that would increase the ballistic limits of 5-inch cast armor plates to meet the minimum ballistic limits of wrought armor (MIL-A-12560D (MR)). Cast plates were produced that did meet the minimum ballistic limits at 0° obliquity of the wrought armor specification. These casting processes were then used to produce a simulated section casting to show the improved ballistic values.

Three simulated section castings, as shown in Figure 1, were produced using the information obtained from the cast plates. Initial ballistic results have shown that castings from all casting companies exceed the ballistic acceptance requirements of rolled homogeneous armor.

Figure 1 - Typical Steel Casting

BENEFITS

The results of ballistic testing showed significantly improved casting quality but the limited data generated was insufficient to verify total capability.

IMPLEMENTATION

No implementation is planned at this time. The follow-on effort, Phase II, Project T81 4586, has been disapproved (letter from DRCMT 15 October 1980) and the funding has been reprogrammed to other programs.

MORE INFORMATION

Additional information on this project may be obtained by contacting Mr. Donald E. Phelps, US Army Tank Automotive Command, AV 786-6433 or Commercial (313) 574-6433.

Summary report, Dec 83, was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **T79 5002** and **T82 5002** titled **"Fabricating Torsion Bar Springs From High Strength Steel"** were completed by the Tank and Automotive Command in June 1983 at costs of $150,000 and $95,000, respectively.

BACKGROUND

Recent improvements in tracked vehicle cross-country mobility have been achieved primarily by increasing wheel travel. The resulting increased torsion bar windup, with proportionately larger stresses, has created a need for higher strength bar materials. For over 25 years, bars produced according to specification MIL-S-45387 have successfully met the test of 45,000 endurance cycles at a stress of 140,000 psi, and the majority of suspension torsion bars have been manufactured from 4150 alloy steel. However, a torsional sheer stress range of 30,000 to 180,000 psi is currently specified for Bradley torsion bar endurance testing and 20,000 to 160,000 psi is specified for the M113A2 bar.

Current Bradley bars and the original M113A2 bars were manufactured of 300M steel to provide the required strength and fracture toughness. 300M is a unique, specialty steel which is costly to procure and heat treat. The lower stressed M113 bars have since been changed to a less costly case hardened 4150 design which readily meets the 45,000 cycle endurance test associated with 6,000 miles of vehicle life.

SUMMARY

The objective of this program was to develop a cost effective high-strength torsion bar for the Bradley system, capable of operating at a design stress of 180,000 psi for the required 45000 endurance cycles. For Phase I, laboratory testing, one heat each of steel alloys 4150 Aircraft Quality, 4350 Aircraft Quality, and 1345 were procured. Tensile and Charpy impact specimens, manufactured from these steels, were subjected to a range of tempering treatments. Based on the results, an optimum heat treatment for each steel was selected. In subsequent laboratory work, torsional shear specimens were employed to define stress/strain relationships required for presetting torsion bars. The steel alloy 1345 mechanical properties were found to be less than program requirements and it was dropped from further consideration.

In Phase II, one-third length torsion bars, processed from the same heats of steel as the laboratory specimens, were fabricated. After receiving optimum heat treatment, shot peening, and presetting, these bars were endurance tested until failure using the test fixture shown in Figure 1.

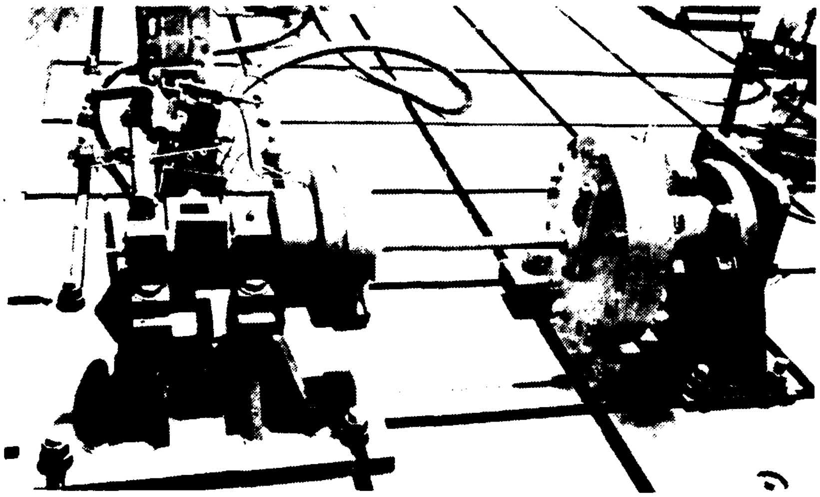


Figure 1 - Torsion Bar Endurance Test Fixture
(Shown with Scatter Shield Removed)

After statistical analysis of test data, 15 Bradley torsion bars were manufactured to the optimized heat treatment and processing parameters from the 4350 steel, which had exhibited the best endurance life. These bars were delivered to TACOM along with a detailed torsion bar manufacturing specification.

Phase III will consist of endurance testing and evaluation of 15 full-size Bradley torsion bars manufactured to optimum material and processing parameters that have been delivered to the TACOM Suspension Laboratory.

This project demonstrated that with optimized heat treatment, 4350 Aircraft Quality, vacuum degassed steel torsion bar specimens, tested to the Bradley torsion bar stress range of 30 to 180 ksi, exhibited an average life of over 83,000 cycles. This performance exceeds the Bradley specification (45,000 cycles) by 84 percent.

BENEFITS

This project resulted in an alternate material specification for the Bradley Torsion Bar, together with its recommended heat treatment and shot peening surface treatment. Based on current market conditions, it is estimated that torsion bar material cost for the proposed 4350 material will be approximately one-third of the cost of the existing 300M material. Since labor costs for processing this design are approximately the same as for processing the design which used 300M material, a cost saving in the order of $1000 per vehicle can be achieved in future production procurements.

IMPLEMENTATION

This material and its processing technology is available for implementation on future procurements and will be recommended as a direct replacement for the 300M material. This recommendation will be subject to a successful laboratory evaluation testing of the 15 torsion bars delivered to the TACOM Suspension Laboratory, and a successful 6,000 mile durability test to provide functional validation.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Michael King at the Tank and Automotive Command, AV 786-5814 or Commercial (313) 573-5814.

Summary report, Dec 83, was prepared by Ken Bezaury, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **477 5097, 478 5097** and **481 5097** titled **"MMT Integrally Cast Low Cost Compressor"** were completed by the US Army Tank Automotive Command in September 1983 at costs of $375,00, $342,000 and $50,000, respectively.

BACKGROUND

The axial compressor stages of the AGT 1500 engine are designed as separately bladed assemblies requiring electrochemically machined airfoils with precision ground roots and related precision broached slots in the disks. Cost savings could be achieved in the AGT 1500 engine by integrally casting axial compressor stages, thereby eliminating many costly machining operations.

SUMMARY

In order to cast the first stage rotor, the design was modified to eliminate the mid-span shroud. Aerodynamic effects from this change also influenced the second stage. A preliminary design was developed for the low-pressure compressor which incorporated the first and second stages as castings. A detailed design and performance analysis of the first and the second stage rotors as investment castings was also conducted. Aerodynamic analysis optimized final airfoil geometry. Stress and vibration analyses determined that the operating stresses of the first and the second stage rotors should be well below the mechanical property capabilities of the selected alloy, Custom 450.

Casting parameter studies were conducted and casting processes for all three stages (first, second and fifth) were defined in order to produce the thin bladed integral rotors. These processes were subsequently used to produce rotors. See Figure 1.

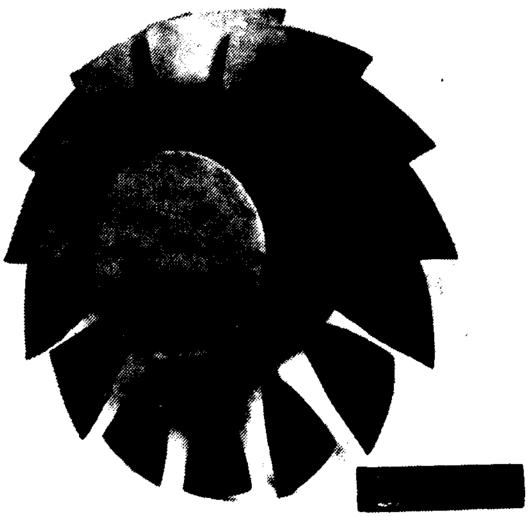


Figure 1 - Leading Edge View

"Engine Runable" castings were produced for the first stage. Second stage castings were also produced, but metallurgical anomalies found late in the program caused concern regarding the fatigue capability in an engine environment. No engine runable fifth stage castings were produced. More rotors will have to be cast to determine if the process is viable from a production standpoint. Fifth stage castings deviate from blueprint dimensions. Therefore, the investment casting tooling would need to be corrected in order to determine if the tooling and process could produce acceptable rotors from a production standpoint.

BENEFITS

Tooling and casting processes were not adequately developed to produce acceptable rotors.

IMPLEMENTATION

The project was unable to develop processes to produce acceptable production rotors. The results of this project will be submitted to the AGT-1500 PIP team for possible inclusion in that program.

MORE INFORMATION

Additional information on this project may be obtained by contacting Mr. Don Cargo, US Army Tank Automotive Command, AV 786-6065 or Commercial (313) 574-6065.

Summary report, Dec 83, was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **578 4158** titled **"Inertia Welder for the M509 and M483 Projectiles"** was completed by the US Army Armament Research and Development Command in September 1982 at a cost of $335,000.

BACKGROUND

The current method of applying rotating bands on the 155mm M483 and 8" M509 projectiles is overlay band welding with a MIG welder. This method has a high scrap rate and a long production cycle making the costs excessive.

SUMMARY

In order to reduce cost, reduce scrap rate and improve quality, the inertia welding technique was selected as the best approach. Inertia welding is a process in which the heat for welding is produced by direct conversion of mechanical energy at the interface of the workpieces without the application of electrical energy or heat from other sources to the workpieces. Welds are made by holding a non-rotating workpiece in contact with a rotating workpiece under constant or gradually increasing pressure until the interface reaches welding temperature and then stopping rotation to complete the weld.

The tests were run on a Materials Technology, Inc. Model 250B Inertia Welder. The band, which is 1.58 inches wide and with a 15° taper, was chucked by means of a 6-jaw chuck into the rotating head stock. The M483 projectile was securely fastened to the tailstock in line with the band.

The headstock of the machine with the band was rotated at approximately 2000 rpm. Once the correct speed had been reached, the tailstock containing the projectile body was moved into the band under pressure until the headstock came to a complete stop completing the weld. A total of 260 projectiles were run in this manner at the optimum parameters to produce a good weld. However, the reject rate was approximately 24 percent and was considered to be unacceptable.

BENEFITS

The reject rate was unacceptable (24 percent) and the project was considered technically unsuccessful.

IMPLEMENTATION

The results of this project will not be implemented because the project was unsuccessful.

MORE INFORMATION

Additional information covering this project may be obtained from Mr. William R. Sharpe, US Army Research and Development Command, AV 880-3742 or Commercial (201) 328-3742.

Summary report, Dec 83, was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects 574 6562 and 575 6562 titled **"MMT Feasibility of Using Continuous Cast Steel for Ammunition Metal Parts Manufacturing"** were completed by the US Army Armament Research and Development Command in January 1979 at a cost of $200,000 and $150,000, respectively.

BACKGROUND

In the United States, continuous cast steel is progressively increasing its share of total billet production. To assure an adequate base of supply of raw material, it was necessary to determine if an acceptable shell could be made from continuous cast steel.

The objective of this project was to determine the suitability of a continuous cast steel product for ammunition manufacture. The 105mm M1 H.E. projectile was selected as the vehicle because it incorporates both hot and cold working in its manufacture. See Figure 1. It also represents a high volume production, and the size of the starting material allows a minimum of 4 to 1 reduction in cross sectional area after casting the billet.

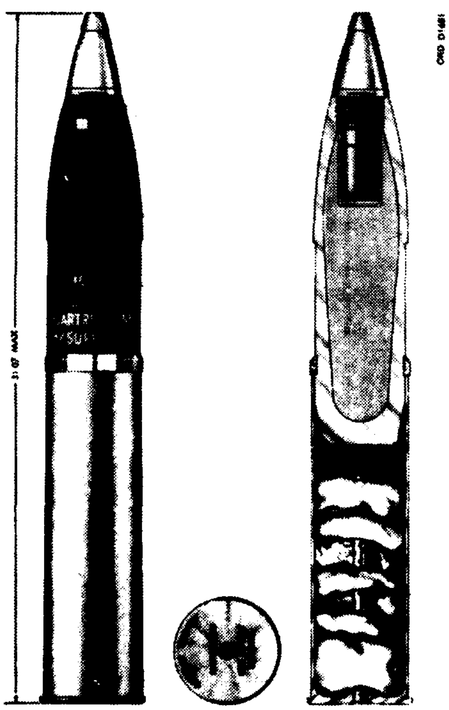


Figure 1 - M-105 Projectile

SUMMARY

The work on the project was performed over two years (FY74 and FY75). During the first year's effort, approximately 25 tons of con-cast steel was rolled into a 3 1/2 inch round corned square product and processed into 105mm M1 projectiles at National Presto Industries. A very limited quantity of as-cast continuous cast material was also evaluated. Differences in processing this material from conventional ingot cast material were noted in NPI's final report on contract DAAA25-75-C-0614. Material that was rolled produced satisfactory shell material. The as-cast material produced unacceptable forgings. The forgings capable of being processed into nosed projectiles produced defective projectiles due to nosing defects. Ballistic testing was performed on projectiles representing the Republic material in accordance with MIL-P-60547C, and this testing was completed satisfactorily.

The FY75 effort consisted of a detailed metallurgical examination of the raw material, process pieces and finished projectiles. Fracture toughness testing at various strain rates and temperature was also performed. Results of the metallurgical investigation concluded that continuous cast material reduced by rolling to a minimum reduction in cross sectional area of 4 to 1 has equivalent quality to that of conventional ingot cast material. An analysis of fracture toughness data indicates the fracture toughness of continuous cast steel processed into projectiles is at least as good as the product made from conventional steel at all test environments.

BENEFITS

This project determined that a continuous cast steel material with a 4 to 1 reduction in cross-sectional area after rolling produces a suitable material for ammunition manufacture. There is no cost reduction at this time as the steel industry has not established a separate price schedule for continuous cast steel.

IMPLEMENTATION

Changes will be introduced into selected Technical Data Packages allowing the use of continuous cast steel reduced by rolling subsequent to casting by a minimum of 75% reduction in cross sectional area.

MORE INFORMATION

Additional information on this project may be obtained by contacting Mr. C. Sallade, US Army Armament Research and Development Command, AV 880-6509 or Commercial (201) 328-6509.

Summary report, Dec 83, was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects 576, 77, 78, and 79 6634 titled **"Manufacturing Processes for Depleted Uranium Large Caliber Armor Defeating Projectiles"** was completed by the US Army Armament, Munitions and Chemical Command in September 1983 at costs of $500,000, $699,000, $400,000, and $560,000, respectively.

BACKGROUND

At the inception of this project, the then current armor defeating projectiles used tungsten penetrators. It was felt that in the event of mobilization, tungsten would be in short supply and an alternate material, as well as the production processes to manufacture it, should be established. It was assumed that depleted uranium would be the alternate material because of its physical properties and availability.

In the metal removal processes of penetrator manufacture, machining chips are generated. Where depleted uranium (DU) is the basic material, those chips must be disposed of in specific ways prescribed by the Environmental Protection Agency and the Nuclear Regulatory Commission. The disposal procedure involves encapsulating the chips in concrete within steel drums and shipping to designated burial sites.

SUMMARY

One alternative to the disposal of DU chips was to recycle them into usable raw material, and efforts to accomplish this constituted the primary thrust of this effort.

The recycling of depleted uranium chips was complicated by the fact that DU is very chemically active and has a propensity to oxidize even to the point of being dangerously pyrophoric. During the machining cycle, oxidation was increased by the presence of moisture in the water based cutting fluid, the heat generated by the process, and the high ratio of surface area to mass of the chip form. The adherent, rigid layer of oxide, once formed on the surface of the chips apparently melts at a higher temperature than the base metal so that it forms a container around the molten metal preventing the formation of a usable mass. Five methods of reducing the chips to usable DU were attempted. They are as follows:

Conversion of Machine Chips to UF_4 - The complications involved as a result of the generation of uranyl fluoride (UO_2F_2) in the reaction to UF4 did not justify continued effort in this approach because of the time and funding constraints.

Co-Reduction of Chips in the UF_4/Mg Reaction Vessels - Early in this portion of the study, the laboratory sized reduction attempts indicated that the potential volume of chip reclamation would be so low as to be not feasible.

Inductoslag Remelting - The effect of the layering of the chips in the molten salt could not be overcome irrespective of long holding times at highly elevated temperatures.

Vacuum Induction Remelting (VIR) - The cost effectiveness of the total recovery process, due to iron and carbon contamination build-up, is in doubt. But the fact that there was a 70 percent yield is thought to justify a more sophisticated and detailed undertaking than was possible under this program.

Electron Beam Remelting (EB) - The EB process holds the greatest promise of success. Yields in excess of 95 percent have been achieved by others with excellent quality and good homogeneity. The chips used in this instance were coarse trimmings which were pickled, rinsed and spun dry prior to melting. Under this project, chips were cleaned, dried, compacted, encapulated in copper and extruded. See Figure 1. The rods thus prepared were EB melted, cast, sectioned and analyzed.

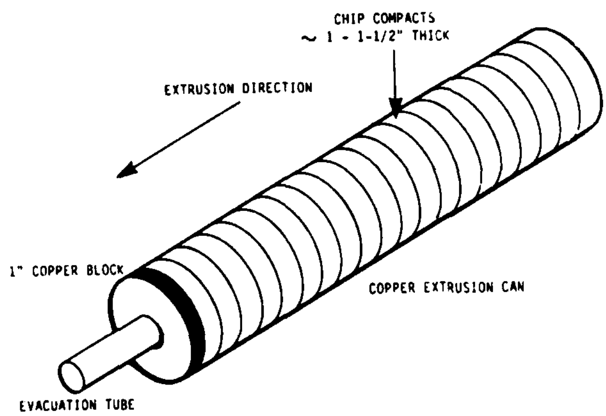


Figure 1 - Extrusion Chip Briquette Assembly

With the exception of correctable iron contamination from the lathe chip conveyor and the briquette compaction die, and low titanium levels (which can be restored) the chemical quality was well within the specification required for core production.

BENEFITS

This project has demonstrated that DU machining chips, using this EB remelting technique, can be recycled into material which meets present core specifications. The titanium level can be restored to the proper value during a subsequent vacuum induction remelt.

IMPLEMENTATION

Although the feasibility of the EB process is established hereby, an in-depth study to establish optimum EB process parameters is felt to be necessary. The estimated $3 million capital investment needed for direct implementation is considered too high a risk without further study.

MORE INFORMATION

Additional information can be obtained by contacting Mr. C. E. Sallade at the US Army Armament Research and Development Command, AV 880-2522 or Commercial (201) 328-2522.

Summary report, Dec 83, was prepared by Ken Bezaury, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **579 6738** and **580 6738** titled **"The Use of Ultra-High Surface Speeds for Metal Removal, Artillery Shell"** were completed by the US Army Armament Research and Development Command in October 1982 at a cost of $478,000.

BACKGROUND

Conventional manufacturing methods for artillery shells require the use of lathes generally operating with spindle speeds in the range of 400 to 500 revolutions per minute. Removing metal at these spindle speeds requires large quantities of equipment to accomplish a particular machining operation. The development of new cutting tools and advances in numerically controlled machine tools have the potential for substantially increasing metal removal rates thereby increasing productivity per machine and reducing capital equipment investment and direct manufacturing costs.

SUMMARY

The objective of this effort was to apply to artillery shell manufacture a technology utilizing metal removal rates substantially in excess of those available in conventional processes. Machining trials were conducted on AISI 1340, AISI 4140, AISI 4340, and HF-1 at two hardness levels using five cutting tool materials. Initial tests were conducted on a 250 horsepower experimental lathe previously developed by the contractor. Verification and refinement of test data were accomplished using commercially available equipment and the results are summarized in Tables 1 and 2.

Table 1 - Summary of Test Data

Material	Ceramic-Coated Carbide			Cold-Press G-30 Ceramic			Hot Press G-10 Ceramic		
	SFM	Feed	Prod. Index	SFM	Feed	Prod. Index	SFM	Feed	Prod. Index
"Roughing" Cuts									
1340	630	.025	15.8	920	.015	13.8	---	---	---
4140	550	.025	13.8	830	.015	12.5	---	---	---
4340	430	.022	9.5	720	.015	10.8	750	.015	11.3
HF-1	410	.022	9.0	640	.015	9.6	600	.015	9.0
"Finishing" Cuts									
1340	460	.015	6.9	700	.015	10.5	670	.015	10.0
4140	360	.015	5.4	660	.015	9.9	600	.015	9.0
4340	300	.015	4.5	---	---	---	300	.011	3.3
HF-1	360	.011	4.0	590	.011	6.5	610	.011	6.7

Table 2 - Comparison of Test Data

Material	Ceramic-Coated Carbide Previous Study[1] SFM	Feed	Prod Index	Current Study SFM	Feed	Prod Index	Cold-Press Ceramic Previous Study[1] SFM	Feed	Prod Index	Current Study SFM	Feed	Prod Index
"Roughing" Cuts												
1340	700	025	17 5	630	025	15 8	830	022	18 3	920	015	13 8
4140	360	033	11 9	550	025	13 8	760	022	16 7	820	015	12 3
4340	400	033	13 2	430	022	9 5	750	022	16 5	760	015	11 4
HF1	420	022	9 2	410	022	9 0	470	022	10 3	640	015	9 6
"Finishing" Cuts												
1340	470	015	7 1	460	015	6 9	660	015	9 9	700	015	10 5
4140	255	015	3 8	360	015	5 4	450	015	6 8	660	015	9 9
4340	180	015	2 7	300	015	4 5	250	015	3 8	300	011	3 3
HF 1	340	011	3 7	370	011	4 1	590	011	6 5	590	011	6 5

[1] Previous study titled **Ultra High Surface Speed for Metal Removal, Artillery Shell**
Contract Report ARLCD-CR-81019

Conclusions drawn and recommendations made at the completion of the effort are shown in Table 3.

Table 3 - Conclusions and Recommendations

Conclusions:

1. Significant increases in metal removal rates for heat-treated steels can be obtained using ceramic cutting tools as compared with the reference ceramic coated tungsten carbide cutting tools.

2. Ceramic tools and ceramic-coated tungsten carbide tools show equivalent tool life when machining steels in the "as forged" condition.

3. Optimum cutting tool life requires infinite spindle speed control through the usable range.

4. Higher cutting speeds require higher horsepower machines.

Recommendations:

1. The use of ceramic cutting tools should be considered for all machining operations.

2. When ceramic cutting tools are used, the tool holders should be designed to accept thicker inserts, have a stable insert pocket, and have a low profile, rugged clamping device.

3. Variable spindle speed control is important for optimum tool life when machining the "as forged" steel and is of paramount importance when machining the heat-treated steels.

4. Feed control, so a consistent tool load can be maintained throughout all tool paths, is required when applying ceramic cutting tools, and would give better tool life when using tungsten carbide tools.

5. The results on the heat-treated 4340 material was inconclusive when ceramic cutting tools were tested and further effort should correct this deficiency.

BENEFITS

This effort has documented the feeds, speeds, and tooling necessary to significantly increase cutting speeds above those presently utilized. Its results are applicable to all projectile machining operations.

IMPLEMENTATION

The technical reports associated with this effort have been distributed to projectile metal parts contractors. In addition, the report is available for unlimited distribution through the Defense Technical Information Center.

MORE INFORMATION

Additional information may be obtained by calling Mr. George O'Brian, Production Base Modernization Agency, AV 880-3730 or Commercial (201) 328-4084, or Mr. Roy Pohl, US Army Armament Research and Development Command, AV 880-3050 or Commercial (201) 328-3050.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project 673 7340 titled **"MMT Determination and Certification of an "In House" Armor Steel Casting Process"** was completed by the US Army Armament Readiness Command in January 1979 at a cost of $83,166.

BACKGROUND

Armor steel castings are difficult to obtain due to small quantities involved and long lead times by the casting vendors. The objective of this project is to resolve the difficulty in procurement of armor steel castings by obtaining certification of an "in house" armor steel casting process, thus providing an additional source.

SUMMARY

The applicable specifications for armor steel were reviewed and a tentative chemical composition determined. Manufacturing procedures were defined and patterns for test blocks and plates were fabricated. Numerous trials pouring and heat treating both one-inch and two-inch armor were made. By adjusting the chemistry and heat treatment, samples were cast which met the Charpy Impact Requirements for the one-inch armor. The one-inch armor plate was sent to Aberdeen Proving Ground for ballistic testing and was passed. Work was continued with the chemistry, casting process, heat treatment, and quenching process to develop a two-inch armor which would meet the required Charpy Impact Requirement. This work was successful and certification to cast two-inch armor was obtained. The development of proper welding procedures and the required welded test plate was begun. The first weld test plate sent to Aberdeen failed the radiographic inspection. A second test plate was prepared and sent for ballistic testing. This plate passed the radiographic inspection and ballistic testing. Certification was obtained for one and two-inch armor steel castings at the Rock Island Arsenal Foundry and was used to suppply castings for the gun mount in Figure 1 and to meet other requirements.

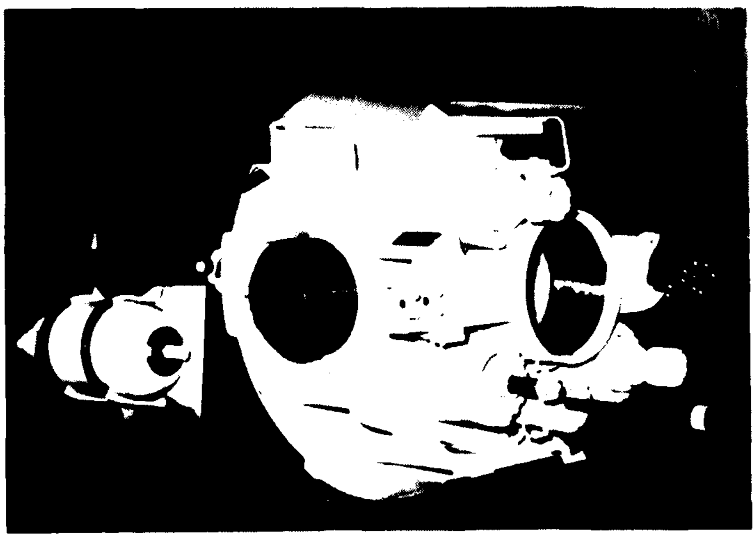


Figure 1 - Gun Mount

BENEFITS

As a result of this MMT project, certification was obtained to pour one-inch armor steel castings at Rock Island Arsenal. This alleviated a serious procurement problem in the area of armor castings. This process is applicable to all armor castings within the one-inch to two-inch range. While no specific cost reductions have been identified, the Rock Island capability does provide an alternative source of supply.

IMPLEMENTATION

The casting process is fully implemented at Rock Island Arsenal, and the following castings are being produced in quantity:

End Item	Component	Part No.
M127 Gun Mount	Rotor	K10921446
M127 Gun Mount	Plate	C10909284
M127 Gun Mount	Door	D10909286
M127 Gun Mount	Cover	K10909280

MORE INFORMATION

Additional information on this project may be obtained by contacting Mr. John Jugenheimer, ARMCOM AV 793-4135 or Commercial (309) 794-4135.

Summary report, Dec 83, was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, Il 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **677 7485** titled **"Application of Chemical Processes to Improve Surface Finish"** was completed by the US Army Armament Material Readiness Command (Benet Weapons Laboratory) in February 1981 at a cost of $309,000.

BACKGROUND

During the manufacture of gun tubes, significant manhours have been required for traditional metal removal operations such as honing, grinding and deburring. In addition, bore cleaning via a water and aluminum oxide slurry blast has caused plating problems due to slurry residue in the gun tube.

SUMMARY

The objective of this project was to develop and demonstrate an electrochemical process capable of replacing existing mechanical surface finishing operations. Test specimens were designed and fabricated for laboratory electropolishing studies to determine surface finish characteristics for various metal removal rates. Fixtures and an anode for a 60mm stub tube were also designed and fabricated.

Tests were conducted at various initial surface finish conditions in order to simulate operating conditions. Initial testing showed good final surface finishes, but several electropolishing cycles were required.

Processing fixtures were then designed to accommodate 105mm test specimens (Figure 1). Flow problems were encountered and the solution feed system was modified. A full length 105mm M68 gun tube was then processed using a partial anode and a pump-through polishing system. Excellent results were obtained in terms of modifying the land configuration to a rounded corner.

Results obtained using a tapered anode were marginal and a conforming anode was designed in an attempt to correct the problem of uneven metal removal. Tests conducted with the conforming anode demonstrated uniform metal removal throughout the chamber while at the same time achieving the required surface finish at an acceptable metal removal rate.

A facility capable of either electropolishing or plating full length gun tubes was then constructed using the parameters defined in the various tests conducted during this project. Computerized process controls are currently being incorporated into the system and will result in an automated electropolishing facility.

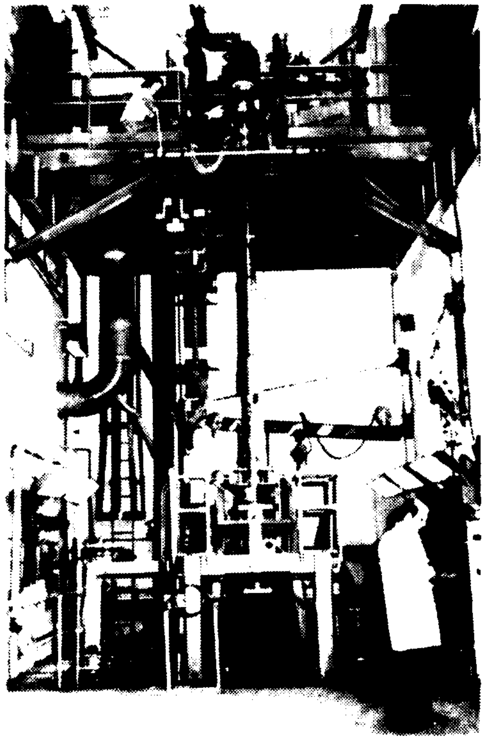


Figure 1 - Tube/Anode Assembly Positioned in Chromium Plating Stand

BENEFITS

The execution of this project has resulted in an electropolishing system for the preparation of gun tube bores prior to plating. This process has eliminated organic and oxidation contaminates, burrs, and surface imperfections previously assocated with traditional mechanical processes and has resulted in a projected annual savings of approximately $60,000.

IMPLEMENTATION

The results of this project have been implemented at Watervliet Arsenal in the production of various gun tubes.

MORE INFORMATION

Additional information may be obtained by contacting Mr. T. M. Pochily, Benet Weapons Laboratory, at AV 974-5717 or Commercial (518) 266-5717.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **677 7652** titled **"Application of Coolant Chip Ejector Tooling"** was completed by the US Army Armament Material Readiness Command (Rock Island Arsenal) in July 1980 at a cost of $65,000.

BACKGROUND

Precision cylindrical components associated with today's recoil mechanisms are increasingly expensive to produce. Boring and reaming tooling used is antiquated and has resulted in the need for many stress relieving and straightening operations.

SUMMARY

The objective of this project was to evaluate and apply coolant chip ejector tooling (Figure 1) to the machining of cylindrical weapons components in order to eliminate multiple operations, reduce scrap, and improve quality.

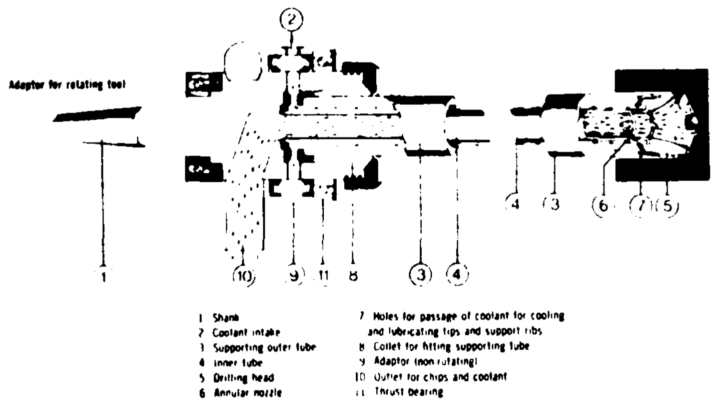


Figure 1 - Schematic of Ejector Drill System For Rotating Tool

Drawings and process planning worksheets for all recoil cylinders and rods were reviewed in order to analyze workpiece material, contour, and tolerance, and to develop groupings of similar parts. Horsepower requirements were calculated and plotted for the various workpiece groupings and compared with existing boring lathes. Performance requirements for standard and special trepanning tools were reviewed with suppliers of ejector tooling, and recoil cylinders were selected for test machining. Coolant requirements were calculated, and existing coolant system capacities were checked and determined to be appropriate.

All ejector type tooling and related machine tool systems were investigated. Particular emphasis was placed on adapting this tooling to the production of short holes.

Double tube coolant inlet counterboring tools were found to be uneconomical for the production of recoil cylinders over 4.750-inches in diameter since existing equipment lacked the required rigidity. One counterboring tooling assembly was found to be capable of machining the bore diameters on two different recoil cylinders and was scheduled for application in the production of these cylinders.

Various makes of carbide indexable insert oil hole drills were evaluated in production drilling. The Sandvik "T-Max U" drill was found to be the most efficient for straight holes in terms of size and finish accuracy, tool life, metal removal rate and cost. The Sandvik "T-Max U" trepanning tool was also tested and found capable of removing metal at a rate of over 2 1/2 cubic inches per horsepower per minute.

Specifications were developed for tooling to handle all of Rock Island Arsenal's major cylinder production. In addition, criteria was established to provide for the comparative analysis of such factors as tool life, penetration rate, and cost.

BENEFITS

The use of coolant chip ejector counterboring on M198 Recoil Cylinders has resulted in a 22 hour per cylinder reduction in machining time and the elimination of a stress relief and rough honing operation. Annual savings are expected to be approximately $450,000.

IMPLEMENTATION

The results of this project have been implemented at Rock Island Arsenal in the production of recoil cylinders.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Ray Kirschbaum, Rock Island Arsenal at AV 793-5363 or Commercial (309) 794-5363.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **680 7920** titled **"Conservation of Critical Material for Gun Tubes"** was completed by the US Army Armament Research and Development Command in December 1982 at a cost of $236,000.

BACKGROUND

The steel industry, through an evolutionary process, has developed an alloy steel which has proven to be satisfactory for a wide range of gun tube forgings. This ultra-high strength, low alloy (UHSLA) steel contains several alloying elements. One element in particular, heavily relied on from foreign countries, is chromium. Amounts of up to 1.0 percent chromium is used in gunsteel. There is a need to reduce the amount of chromium utilized, thereby decreasing our reliance on the importing of the material.

SUMMARY

The objective of this project was to reduce heavy reliance upon foreign sources for chromium, which is a critical element in steels presently used in numerous weapon systems. The approach was to substitute another alloying element for some of the chromium. Chromium may be replaced to some extent but cannot be completely eliminated. Reducing the amount of chromium was to be done without sacrificing mechanical properties or creating problems in other aspects in the manufacture and service of a gun tube, e.g., in forgeability, machinability, hardenability, etc. Substituting another element for chromium is a complex task. There are many subtle, complex, synergistic interactions between metallurgical variables and physical constraints. For example, greater heating will dissolve more alloying element into austenite, assuring a better transformation to martensite which would improve the properties. However, increased heating will also increase the grain size and thus lower ductility, impact and fracture toughness. Greater amounts of alloying elements increase the hardenability, but decrease the quench temperature of steel in order for the martensitic transformation to start and finish. Chromium imparts hardenability, temperability, general corrosion resistance, and secondary hardening to steels.

Molybdenum (Mo) and manganese (Mn) were selected as potential elements to be varied from the gunsteel composition. Molybdenum exerts a marked influence on hardenability when dissolved. Manganese is also effective in hardening steel although it has a tendency to cause the steel to become brittle.

Steel specimens were evaluated with varying amounts of Mo, Cr, and Mn. The results indicated that the best compositions were those with varying amount of Mo and Cr. The results of the hardenability tests indicated that chemical compositions with Cr less than .40 percent show inferior hardenability as compared to gunsteel. Overall, composition no. 10 appeared to be the better choice based on evaluations provided in Figure 1.

HEAT CODES	C	Mn	Ni	Mo	Cr	V	Si	P	S
5	.365	.68	2.3	1.7	.38	.1	<.01	<.010	.0042
6	.372	.70	2.2	1.4	.52	.1	<.10	<.01	.0055
7	.347	.70	2.2	1.7	.54	.1	<.10	<.01	.0051
8	.340	.70	2.3	1.5	.54	.1	<.10	<.01	.0054
9	.343	.69	2.2	1.9	.35	.1	<.10	<.01	.0051
10	.377	.72	2.2	1.1	.57	.1	<.10	<.01	.0048
Gunsteel	.32/.36	.55/.65	2.1/2.25	.45/.55	.9/1.1	.09/.12	<.10	<.01	<.01

Figure 1 - Small Heat Chemistries

A preform of this composition was austenitized at 1600°F, spray quenched with water on the outer diameter surface and tempered at 1125°F. The results showed no variability over the length of the tube and sufficient hardenability. Due to secondary hardening effects, higher levels of molybdenum in the gunsteel required heat treatment at higher tempering temperatures to develop acceptable mechanical properties.

BENEFITS

Chromium can be reduced to .5 percent in gunsteel by increasing the molybdenum to 1.0 percent without sacrificing hardenability. The .5 percent reduction of chromium could result in a savings of $.05 to $.10 per pound of low chromium gunsteel. Based on $.05 per pound of steel, it is estimated that $778,000/yr. savings could be realized by using the reduced chromium gunsteel in the production of 105mm gun tubes.

IMPLEMENTATION

Engineering personnel determined that additional data on fracture toughness tests was required prior to submission of an Engineering Change Proposal (ECP). These tests will be completed by the end of FY83, at which time an ECP will be submitted for project implementation.

MORE INFORMATION

Additional information is available in DRDAR-LCB-SE final technical report titled "Conservation of Critical Materials for Gun Tubes" dated 31 December 1982 or from the Watervliet Arsenal Project Officer, Mr. Steven G. Tauscher, AV 974-5517 or Commercial (518) 266-5517.

Summary report, Dec 83, was prepared by Bob Hellem, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **681 7940** titled **"Synergistic Platings With Infused Lubricants"** was completed by the US Army Armament Research and Development Command in September 1982 at a cost of $121,000.

BACKGROUND

The development of rapid fire weapons has resulted in increased wear in many of the moving parts. Present dry film lubricants, as well as greases or oils, tend to wear off with use and, therefore, require frequent reapplication or reservoirs. Such maintenance or built-in reservoir systems are not practical. The environment to which armaments may be exposed include dirt and water. Therefore, the coating must resist wear from the abrasive cutting action of dirt and it should be resistant to corrosion in wet environments. There is a requirement for a hard, self-lubricating coating for sliding surfaces.

SUMMARY

The purpose of this program was to adapt a known hard nickel-phosphorous deposition process to form porous coatings, impregnate the coatings with dry lubricants, and evaluate friction and wear properties of the deposits. Porosity was varied over a wide range by changing the concentration of the activated carbon particles in the plating solutions. Three concentrations (5, 10, and 15 g/l) were used to produce 125 μm thick deposits with three different apparent porosities. The apparent porosity was estimated to be 10, 20, and 40 percent of the plated, geometric area respectively.

The phosphorous content of the electroplated nickel-phosphorous alloy is influenced by operating parameters such as pH, temperature, current density, and phosphorous acid (H_3PO_3) concentration. In order to independently study the effects of each of these, four separate alloy plating baths were set up containing four concentrations of phosphorous acid. A series of plating tests were conducted at three different current densities and electrolyte temperatures. Phosphorous content in the deposit rose rapidly with increasing phosphorous acid in the bath until the bath contained about 2 g/l of H_3PO_3. Disproportionately large additions were required to attain higher levels of phosphorous in the deposit.

The original Brenner bath was operated at high hydrogen ion concentration (pH 0.5), thus the nickel deposition efficiency was low (55 to 75 percent). A modified solution was used on this program which resulted in higher cathode efficiencies, primarily due to increased pH (pH=2.0 to 2.5). The rate of nickel concentration build-up was lessened by improving the cathode efficiency of the plating bath. In general, however, the phosphorous concentration in the deposit increased slightly for current ranging from 11.6 amp/dm^2 to 23

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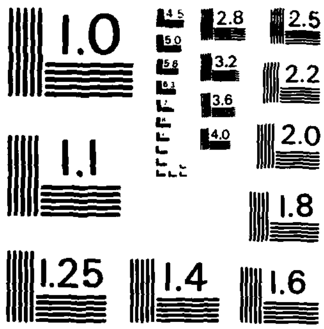


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

amp/dm^2. No definite trend for phosphorous content was established for the narrow temperature range (60 to 71°C) that was investigated. The data show that maximum as-plated hardness may be found in alloys with about 3 to 4 percent phosphorous. See Figure 1. Deposits with higher as-plated phosphorous content tended to be softer.

Phosphorous Content Range in Deposit, Percent	Average Knoop Hardness [a] Before Heat Treatment	Average Knoop Hardness [a] After Heat Treatment[b]
1.5 - 1.9	532	644
2.0 - 2.9	585	697
3.0 - 3.9	606	717
4.0 - 4.9	570	897
5.0 - 6.0	569	852

[a] Knoop hardness numbers, with 100 g load.
[b] Heat treatment for 1 hour in air at 400°C, then cooled to room temperature.

Figure 1 - Hardness of Heat Treated Alloy Plates

Heat treatment increased the hardness of the nickel deposit in proportion to the phosphorous content. The single highest hardness value recorded was 1055 KHN (Knoop hardness number) for a heat treated specimen containing 4.4 percent phosphorous.

Wear and friction testing was conducted on an LFW-1 test machine. Heat hardened coatings containing 5 percent phosphorous had the lowest wear scar depth and low coefficients of friction. Teflon impregnated specimens developed little vibration and were therefore capable of running the full 500 cycles of the test. Coatings with the highest porosity, plated from nickel-phosphorous baths containing 15 g/l activated carbon, had less wear and lower coefficients of friction than less porous deposits.

Corrosion currents were measured for nickel-phosphorous alloy coatings coupled with steel in salt water solutions. The data indicate that the most significant factor influencing galvanic corrosion is the area effect; current densities of about 60 μamp/cm^2 were obtained for specimens of equal area; whereas, values as high as 550 μamp/cm^2 were observed for couples having a 20:1 cathode to anode area. No significant influence on the corrosion rate of steel was noted for cathodes which were either heat treated or that contained occluded carbon particles exposed on the surface of the deposit.

BENEFITS

This program has established an approach for combining porous nickel plating with nickel-phosphorous alloy electrodeposition. A hard, porous coating of nickel-phosphorous can be deposited in sufficient thickness and porosity to provide a wear resistant, composite coating when impregnated with a suitable lubricant.

IMPLEMENTATION

The work accomplished in this project to adapt a known hard nickel-phosphorous process to form porous coatings will be continued. With the data obtained from this project, it will now be possible to establish the process to the pilot stage for producing experimental quantities of coated parts. Operation of a pilot facility will allow refinement of variables such as particle size and content and lubricant formulation. Project No. 682 7940 is the follow-on project.

MORE INFORMATION

Additional information may be obtained by contacting R. Jackson/M. Mankabadi, ARRADCOM, AV 880-5746 or Commercial (201) 328-5746. Also, Technical Report ARSCD-CR-83010 titled "Improvement of a Method for Composite Bearing Coating" was published in June 1983.

Summary report, Dec 83, was prepared by Bob Hellem, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **679 7948, 680 7948,** and **681 7948** titled **"Establish Cutting Fluid Control System"** were completed by the US Army Armament Material Readiness Command (Rock Island Arsenal) in January 1981, May 1982, and August 1983 at costs of $150,000, $158,000, and $164,000, respectively.

BACKGROUND

Cutting fluids at Rock Island Arsenal have been historically procured using trial and error procedures. A cutting fluid was purchased and used for a machine or group of machines. If it performed satisfactorily, it was accepted and used on a permanent basis. This non-quantitative empirical approach often lead to the selection of cutting fluids which did not produce the lowest life cycle cost because the cost savings associated with the optimum cutting fluid was unknown.

SUMMARY

The objective of this three-year MMT effort was to establish a cutting fluid control system and thereby achieve improvements in machining through cost effective control of cutting fluid selection, stocking, distribution, testing, application, maintenance, and disposal. The first year was devoted to the development of systematic quantitative procedures for the evaluation of various cutting fluids relevant to manufacturing requirements at Rock Island Arsenal. These procedures included the development of a manufacturing severity index, the characterization of potential fluid chemistries, development of a test plan to be used for the construction of a fluid composition applications matrix, a definition of process economics, and the development of a preliminary fluid application matrix. The second year included work devoted to refinements in the severity index and the fluid applications matrix, and the third year was devoted primarily to the development of an arsenal wide cutting fluid control system.

Processes investigated and the process variables controlled or monitored are shown in Table 1 below.

Table 1
STUDY PARAMETERS

GRINDING	MILLING
Wheel Grade	Tooling
Wheel Speed	SFM
Table Speed	Chipload
Cross Feed	Feed
Total Depth of Cut	Cutter Diameter
Infeed	Depth of Cut
Wheel Dressing Method	Material
Material	

TURNING/BORING	DRILLING
Tooling	Tooling
SFM	SFM
Feed	Feed
Depth of Cut	Hole Geometry
Material	Material

After extensive machining tests, the following conclusions were reached:

1. The majority of machining operations observed were performed with state-of-the-art technology.

2. Chipping and cratering were observed as the most prevalent form of tool wear.

3. Anerobic bacteria is the main reason for cutting fluid sump changes.

4. Cutting fluid concentrations are not maintained at manufacturer's recommended levels.

5. All of the turning carbide tools tested failed due to flank wear.

6. Milling is a lubrication sensitive process.

7. Turning is a temperature sensitive process.

8. Approximately 90 percent of all water soluble cutting fluid needs can be filled with two cutting fluid formulations.

9. Fluid flow rates have a definite affect on machining efficiency.

10. Cutting fluid manufacturers' classification systems can be misleading.

11. Eight fluids tested demonstrated a tendency to cause rusting during fluid evaluation tests.

12. Rock Island Arsenal requires some form of cutting fluid recycling system.

The following recommendations were made as actions having the potential to reduce Rock Island Arsenal's operating costs:

1. Mix cutting fluids with a positive displacement pump.

2. Add bacteria controlling agents to problem machine sumps.

3. Mix the makeup cutting fluid to the dilution ratio required for a particular machining operation.

4. Monitor the concentration levels of all machine sumps.

5. Institute a machine cleaning program.

6. Conduct a study to characterize the microstructure of workpiece material.

BENEFITS

The execution of this three-year MMT effort has resulted in the development of improved operating procedures for the selection, preparation and use of cutting fluids at Rock Island Arsenal. A positive displacement pump to prepare cutting fluid emulsions has been adapted as a result of this effort. Its use has produced a current annual savings of $25,000. Projected annual savings associated with the implementation of improved cutting fluid procedures in the milling and turning areas of Rock Island Arsenal is estimated to be approximately $580,000. If central coolant systems are installed, the total potential savings associated with this effort is approximately $1,200,000.

IMPLEMENTATION

The results of this three-year effort are currently being implemented at Rock Island Arsenal.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Robert Johnson, Rock Island Arsenal, AV 793-5424 or Commercial (309) 794-5424.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **679 7963** titled **"Group Technology for Fire Control Component Parts and Assemblies"** was completed by the US Army Armament, Munitions and Chemical Command in December 1982 at a cost of $188,000.

BACKGROUND

Group Technology (GT) is a manufacturing concept where parts are systematically classified and coded allowing the formation of part families based upon manufacturing and design similarities. By grouping small lots into part families, the economics of large lot size production can be partially realized in typical job shop environments.

A previous MMT Project (675 7430) established the basic GT requirements for fire control parts and assemblies. A computerized GT system was purchased and installed and approximately 1100 parts were coded.

SUMMARY

The objective of this project was to develop a pilot integrated design and manufacturing system based upon GT concepts. The GT system previously installed was enhanced with additional analysis programs. Codes were developed for machine tools, materials, products, and end items. Approximately 2400 additional parts were coded bringing the total to 3500.

A code number analysis was performed to find preliminary families of similar parts by relating part characteristics to machining requirements. The analysis indicated that approximately 70% of the parts analyzed fell into appropriate manufacturing families. It was estimated that further detailed analysis could raise this to about 90%.

A "Computer Aided Group Technology Scheduling Software Program for Use at Production Shop Level" was developed and programmed in BASIC for use on a microcomputer. This software provides the shop foreman a practical objective means of adjusting schedules as conditions change.

BENEFITS

Proper application of GT principles will lead to manufacturing standardization and provide the Army insight into computer integrated manufacturing.

IMPLEMENTATION

This technology will be available for implementation upon the completion of MMT Project 680 7963.

MORE INFORMATION

Additional information and a copy of the final technical report titled "Pilot Computerized Integrated Design and Manufacturing System" is available from Mr. Nathaniel Scott, Jr., AMCCOM, AUTOVON 880-6945 or Commercial (201) 328-6945.

Summary report, Dec 83, was prepared by J. Sullivan, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **680 7985** titled **"Small Arms Weapons New Process Production Technology"** was completed by the US Army Armament Research and Development Command in June 1983 at a cost of $382,000.

BACKGROUND

Gun barrel processing technology for small arms and large bore guns is well established and has remained close to the state-of-the-art. However, manufacturing technology in the medium caliber barrel area has lagged far behind.

Equipment and processes for manufacturing medium caliber gun barrels, defined in this effort as .50 caliber through 40mm, have changed little since the 1940's for the following reasons. It is difficult for private industry to justify the investment for new equipment on the basis of normal one year contracts. Production volumes have been low, resulting in under utilization of available equipment. Equipment capable of handling workpieces ranging in lengths up to 125", weighing up to 500 pounds, and having small diameters in relation to length is not common; and little equipment development has occurred relating directly to barrels of this size. The resulting production base is made up of equipment from government surplus inventory and other sources of used equipment which has been rebuilt, modified and retrofitted to be made suitable for the purpose. Some of the equipment are truly novel solutions to the problems faced; however, the lack of modern controls and the inability to achieve the increased power and speed possible with today's cutting tools continues to place these processes behind the current capability.

SUMMARY

This effort was initiated with a survey of prior technical studies and a review of the current barrel manufacturing processes in order to identify the key processing areas. Key areas were considered to be those which established critical finished part characteristics, were responsible for a disproportionate amount of barrel cost, caused production bottlenecks, or otherwise offered significant potential for improvement. New manufacturing processes and equipment were then identified as candidates for application in these key areas and a preliminary process, based around precision rotary forging, was developed. The key areas addressed in the new process were hot rotary forging, heat treating, bore drilling, bore preparation, cold rotary forging, O.D. machining, straightening and chrome plating. Verification tests were conducted in order to establish that the proposed new processes and equipment were indeed capable of performing as planned. The preliminary process was revised, as required by the results of the verification tests, to form the proposed new process. Layouts were designed incorporating the number

of machines required to meet peacetime production volumes. The forging trials were conducted on a new GFM model SX13, equipped with full CNC control, and under the under the supervision of a GFM forging specialist. The SX13 used is similar but slightly smaller than the SHP16 which would be required to accommodate the full range of .50 caliber through 40mm barrels. Figure 1 shows the 30mm (GAU-8) barrel being forged in the initial reduction pass.

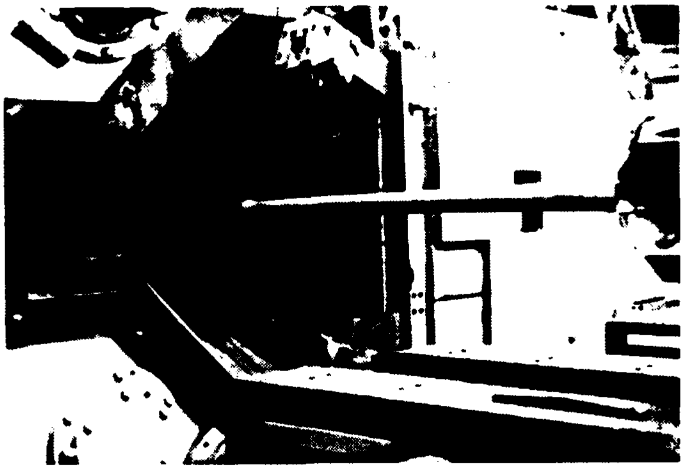


Figure 1 - Workpiece Nearly Finished (GAU-8)
From Exit Side of GFM Rotary Forge

Based on this first phase of the total effort (FY80-FY85), the following conclusions were drawn:

1. Significant improvements in costs can be achieved by modernizing the medium caliber barrel production process.

2. Hot rotary forging was well suited for the production of close tolerance contoured barrel blanks with speed, quality, and versatility.

3. A vertical continuous heat treat system fed directly from the hot forge was the most desirable method.

4. Induction heating was the best method for automatically heating billets for hot forging.

5. BTA bore drilling was capable of meeting hole size and runout tolerances at significantly higher penetration rates than other systems.

6. Bore surfaces prepared by honing, broaching, and electropolishing resulted in satisfactory cold forged surfaces.

7. Cold forging was capable of producing constant twist barrels, complete with throat and rifling, with a finish which required no electro-polish operation prior to chrome plating.

8. CNC turning equipment utilizing ceramic and coated carbide inserts can successfully achieve faster stock removal and eliminate secondary machining operations.

9. The barrels used in this study were sufficiently different in design to cause equipment layout to be grouped by common machine rather than by straight line.

10. Current gain twist barrel designs (gain twist) do not lend themselves to taking full advantage of the cold forging process since the rifling must be separately accomplished.

BENEFITS

Initial estimates project savings in excess of two million dollars per year when the total effort is implemented. This project establishes the direction for the balance of the effort.

IMPLEMENTATION

This is the first year of a six-year effort. The findings of this project will be incorporated in the ongoing effort.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Robert Pizzola of the Armament Research and Development Command at AV 880-4512 or Commercial (201) 328-4512.

Summary report, Dec 83, was prepared by Ken Bezaury, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **678 8047** titled **"Pass Through Steady Rest for Tube Turning"** was completed by the US Army Armament Material Readiness Command in April 1981 at a cost of $129,000.

BACKGROUND

During the machining of cannon tubes, significant transverse forces are generated making it impossible to meet dimension and surface finish requirements without supporting the tube at its longitudinal center. An attempt was made to acquire an adequate pass through steady rest as part of an equipment acquisition. The steady rest obtained did not meet its total specification but did provide a basis from which to pursue the development of a fully operational pass through steady rest.

SUMMARY

The objective of this project was to develop the design for a pass through steady rest for machining the full length of a gun tube in one setup. An engineering study was conducted to determine the support pressure required to safely retain various gun tubes during exterior turning operations, and an industrial survey was accomplished to determine whether or not commercially available systems were applicable. All currently available systems were judged to be unsatisfactory and a design was developed for an electronically actuated system. Engineering requirements for both primary and support equipment were completed and have been incorporated into a procurement specification package.

BENEFITS

The execution of this project has resulted in the development of a design for a pass through steady rest. A time savings of approximately four hours per tube is anticipated for all gun tube turning operations.

IMPLEMENTATION

This project is the first year of a two-year effort. Implementation will be addressed upon completion of MMT 680 8047.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Gary Conlon, Benet Weapons Laboratory, AV 974-5737 or Commercial (518) 266-5611.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **680 8062** titled **"Rapid Internal Threading"** was completed by the US Army Armament Material Readiness Command in September 1982 at a cost of $69,000.

BACKGROUND

The first rapid threading units were developed at Watervliet Arsenal in 1958. As the technique was expanded to include more varied weapons production, minor improvements to the process were made. It was not until the early 1970's, however, that a rapid internal threading system became a reality. It incorporated an automated lathe cycle, carbide form slugs, and an upgraded feed system. Despite these developments, internal threading has remained a production bottleneck.

SUMMARY

The objective of this project was to perform the engineering and design work necessary for the procurement of a universal internal threading system capable of producing located and complex English and metric threads in a variety of breech rings. The two major machining concepts considered for application were milling and turning. The milling concept was rejected because it would have required a dedicated thread milling machine and a tooling package consisting of either high speed steel form mills or indexable carbide insert mills. The turning concept, however, presented the opportunity to use a vertical turning center and offered significant flexibility in terms of tooling systems. After considering component weight and geometry, as well as the limited access to machined surfaces, the turning concept was selected and a specification was prepared for an internal threading system that could be retrofitted to an existing vertical turning center.

BENEFITS

This project has resulted in the development of specifications for an internal threading system which is expected to substantially reduce machining time for the internal threading operation.

IMPLEMENTATION

This project represents the first year of a two-year effort. Implementation will be addressed upon completion of the total effort.

MORE INFORMATION

Additional information may be obtained from Mr. Gary Conlon, Benet Weapons Laboratory, AV 974-5737 or Commercial (518) 266-5737.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **680 8105** titled **"Establish Rough Thread Blanks, 8" M201 Bushing"** was completed by the US Army Armament Material Readiness Command in September, 1982 at a cost of $88,000.

BACKGROUND

The breech mechanism for the 8" M201 is configured with a single lead thread produced on two different diameters. A third non-threaded step provides for longitudinal engagement of the components while a 30 degree rotation produces a thread engagement of 65% of the periphery of the thread diameter. It is thus possible to achieve maximum thread engagement very rapidly, creating a mechanical union capable of withstanding high chamber pressures.

Improvements in finish threading operations have been achieved and have highlighted the need to apply more efficient processes to the production of rough thread blanks.

SUMMARY

The objective of this project was to evaluate various options for machining step thread blanks, select the one best suited to breech mechanism production, design the tooling system and prepare an equipment specification. Electrical discharge machining (EDM), electro-chemical machining (ECM), broaching, milling, and multiple slotting were investigated both for economic viability and adaptability to the production of internal and external thread blanks.

EDM and ECM were determined to be applicable to both internal and external threads but were rejected because of low productivity rates, high operating costs, and specialty equipment and fixturing requirements. In addition, the electrolyte associated with the ECM process was highly corrosive and produced a sludge that presented disposal problems.

Broaching was determined to be practical for external thread blanks only. In addition, it would have required specialized equipment and extremely expensive tooling and, therefore, was also rejected.

Conventional milling was determined to have no significant advantages over the present slotting process which is accomplished in two operations. High horsepower CNC milling machines capable of utilizing up to two inch diameter milling cutters, were deemed to be advantageous over existing external thread blank production processes. The large milling cutters, however, did not have enough clearance to be of significant value for the machining of internal thread blanks.

An extension of the present slotting process using multiple slotting tools was determined to be the best approach for machining internal thread blanks. (See Figure 1). A specification was prepared for all equipment, fixturing, and controls necessary to modify existing slotting equipment.

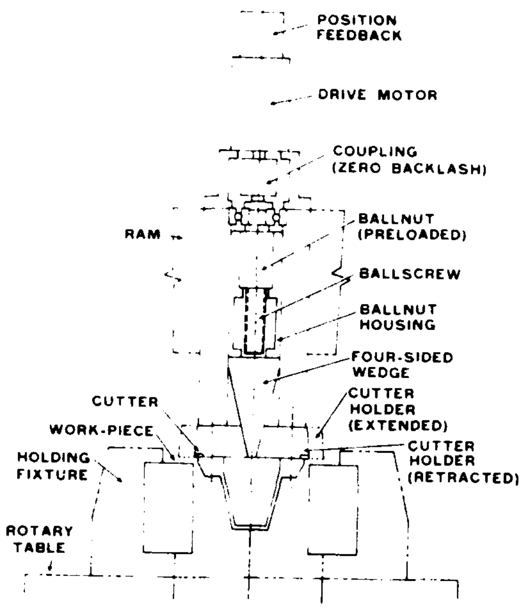


Figure 1 - Thread Blank Slotting Head

BENEFITS

The execution of this project has resulted in the specification of equipment for rough thread blank production which is estimated to reduce production time by over three hours per component.

IMPLEMENTATION

This project represents the first year of a two-year effort. Implementation will be addressed upon completion of the total effort.

MORE INFORMATION

Additional information may be obtained from Mr. Joseph Bak, Benet Weapons Laboratory, AV 974-5611 or Commercial (518) 266-5611.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **680 8106** titled **"Large Caliber Powder Chamber Boring"** was completed by the US Army Armament Research and Development Command (Benet Weapons Laboratory) in September 1982 at a cost of $59,000.

BACKGROUND

Large caliber powder chambers (see Figure 1) produced at Watervliet Arsenal require four machining operations - rough contour boring, semifinish grinding, finish grinding prior to chrome plating, and final grinding after chrome plating. The contour boring operation is accomplished via a single edge cutting tool in a boring bar which is positioned by a hydraulic cam tracer. Deflections of the boring bar, due to unbalanced cutting forces, reduce the accuracy of the boring operation necessitating the semifinish grinding operation.

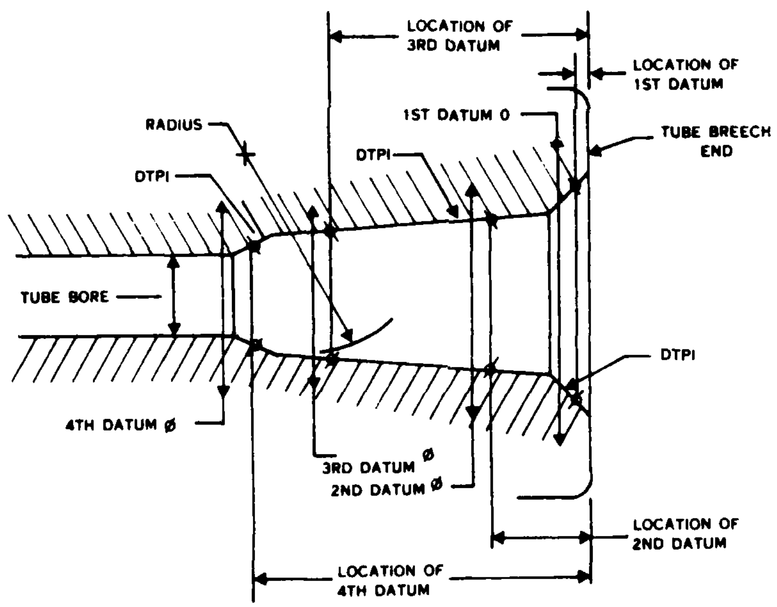


Figure 1 - Typical Powder Chamber Configuration

SUMMARY

The objective of this project was to perform the engineering necessary to establish tooling and power concepts and to prepare equipment specifications for the application of a balanced tooling system in order to eliminate tooling deflection. An engineering analysis was conducted in order to evaluate various techniques which could be used in a balanced tool boring system. A mechanical design was rejected because it was determined that the tool drive and positioning mechanisms required would be too elaborate and restrictive. Similarly, a hydraulic design was rejected because the limited space available within the cannon tube bore would restrict efficiency of the hydraulic system. The mechanical and hydraulic designs were also rejected because both lacked flexibility and would have required extensive changeover and setup time to switch from one powder chamber detail to another.

It was determined that an electromechanical positioning system with CNC control would be the best design approach. Such an approach simplifies the control of tool movement by using software instead of elaborate and dedicated mechanical assemblies for the generation of powder chamber contours. The CNC electromechanical system concept is shown in Figure 2. It is comprised of a programmable computer control, a DC servo driven positioning device, a balanced tool boring bar, a linear measuring device, and a tool gaging station. The concepts associated with this system have been tested on a scaled-down working model and virtually all design parameters have been finalized.

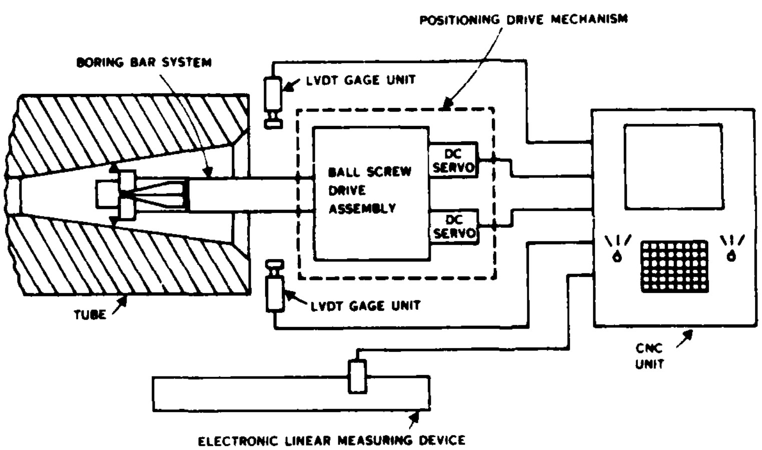


Figure 2 - Powder Chamber Boring System

Follow-on projects will be used to procure, install, and test all required equipment, develop production applications, and document equipment designs and operating parameters.

BENEFITS

This project has resulted in the development of equipment designs for a balanced tool system which can be used for contouring large caliber powder chambers.

IMPLEMENTATION

This project was the first year of a three-year effort. Implementation will be addressed upon completion of the total effort.

MORE INFORMATION

Additional information may be obtained from Mr. Alex Wakulenko, Benet Weapons Laboratory, AV 974-5611 or Commercial (518) 266-5611.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **679 8107** titled **"Creep Feed Crush Form Grinding"** was completed by the US Army Armament Material Readiness Command (Benet Weapons Laboratory) in April 1981 at a cost of $82,000.

BACKGROUND

Developments in crush form abrasive grinding of cylindrical components had proven the economic advantages of that process. The same technique had not been applied to flat components but was considered to have the potential to replace both milling and conventional form grinding operations.

SUMMARY

The objective of this project was to develop engineering data and specifications for grinding equipment capable of machining various breech ring surfaces in a single pass. Test billets were designed to simulate the 105mm M68 breech ring bracket slot and were shipped to a contractor for finish machining via a creep feed crush form profile grinding process. Test results were positive and the engineering data obtained was used to finalize machine specifications. Parameters were also established for feed rates, wheel speed, wheel material, crush roll material, and coolant type.

BENEFITS

The execution of this project has resulted in the development of specifications for creep feed crush form grinding equipment which will be suitable for the grinding of 105mm M68 breech ring bracket slots.

IMPLEMENTATION

This project is the first year of a three-year effort. Implementation will be addressed upon completion of the total effort.

MORE INFORMATION

Additional information may be obtained from Mr. Gary Conlon, Benet Weapons Laboratory, AV 974-5737 or Commercial (518) 266-5611.

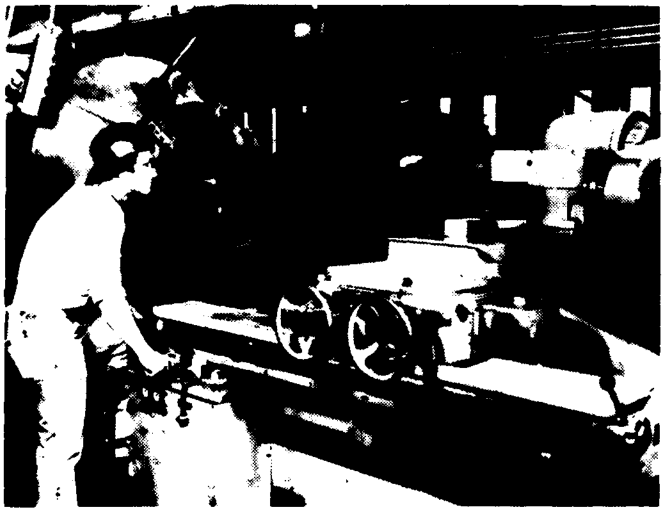
Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **681 8246** titled **"Improved Finishing of Gas Check Seats"** was completed by the US Army Armament Material Readiness Command in June 1982 at a cost of $61,000.

BACKGROUND

A hollow spindle, powder chamber grinder (Figure 1) is utilized to finish grind the gas check seat for 155mm M185 gun tubes.



The tubes are supported at the center only, leaving approximately 12 feet of the muzzle end of the tube unsupported. This unsupported length of gun tube, coupled with existing tube runout, has lead to an unacceptably high degree of eccentricity in the gas check seat and resulted in a rework rate of nearly 30 percent.

Figure 1 - Existing Gas Check Seat Finishing Equipment

SUMMARY

The objective of this project was to develop an improved process for gas check seat finishing by combining an in-house developed design with commercially available equipment. Early in the investigations, it was determined that the most promising approach was to support the gun tube in a stationary position and rotate the grinding wheel around the surface of the gas check seat. Inquiries to several spindle manufacturers revealed that suitable off-the-shelf equipment was not available. A detailed design was then developed around the basic concept described above.

Salient features of this design include a specially designed and constructed grinding wheel spindle that can be rotated in a circular or planetary motion, a special spindle housing, a separate precision aligned lapping spindle, and support fixtures to hold the gun tube firmly during the machining process.

BENEFITS

The execution of this project has resulted in the development of a design for an improved gas check seat finishing process. Expected benefits associated with this process are the elimination of machine spindle bearing stress, easier loading and unloading, the elimination of costly rework, reduced maintenance costs, and improved grinding wheel spindle rigidity.

IMPLEMENTATION

This project represents the first year of a two-year effort. Required equipment will be manufactured and tested during the second year of funding. Implementation is planned at Watervliet Arsenal in mid-1984.

MORE INFORMATION

Additional information may be obtained from Mr. Gary Conlon, Benet Weapons Laboratory, AV 974-5737 or Commercial (518) 266-5737.

Summary report, Dec 83, was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **R80 1018** titled **"Improved Manufacturing Processes for Dry Tuned Accelerometers"** was completed by the US Army Missile Command in June 1983 at a cost of $380,000.

BACKGROUND

The search for a high reliable low cost inertial grade accelerometer led to the development of a novel design based on the well defined performance characteristics associated with dry tuned rotor gyros. The basic change in the evolution of the dry tuned accelerometer was to replace the spinning gyro wheel with a mass-unbalanced suspended on dry flexure supports. However, the flexure supports suspending the two axis dry-tuned accelerometer are costly and difficult, if not impossible, to machine with conventional techniques. The detail of the required machining task is depicted in Figure 1.

SUMMARY

The objective of this program was to develop improved manufacturing methods and technology for dry-tuned accelerometer suspensions. The program goal was to reduce suspension cost by a factor of 2.

The program was divided into six parts: 1) review of suspension requirements, 2) selection of processes, 3) development of processes, 4) fabrication of 24 suspensions, 5) assembly of 12 accelerometers, and 6) evaluation of 12 accelerometers. After verifying the design in light of environmental and performance requirements, four electrical machining processes were investigated: 1) electrical discharge machining (EDM), 2) electrical discharge wire cutting (EDWC), 3) electrochemical machining (ECM), and 4) electrochemical grinding (ECG). Based upon this evaluation the EDM process was chosen.

The EDM process development phase was directed toward fabrication, quality assurance, and a cost study. A number of machining parameters including machine settings (spark intensity, pulse width, travel rate), dielectric fluid, and electrode material and geometry were optimized and a process plan was developed. Quality assurance techniques including visual inspection criteria and measurement requirements were determined. Operator requirements including skill level were determined.

A cost study based upon the new process plan was made. Using a production rate of 150 per month, the suspension was estimated to cost $180 each. This is composed of $122 labor and $58 equipment amortization.

Using the process developed, 24 suspensions were fabricated; 12 of these were installed in accelerometers and evaluated.

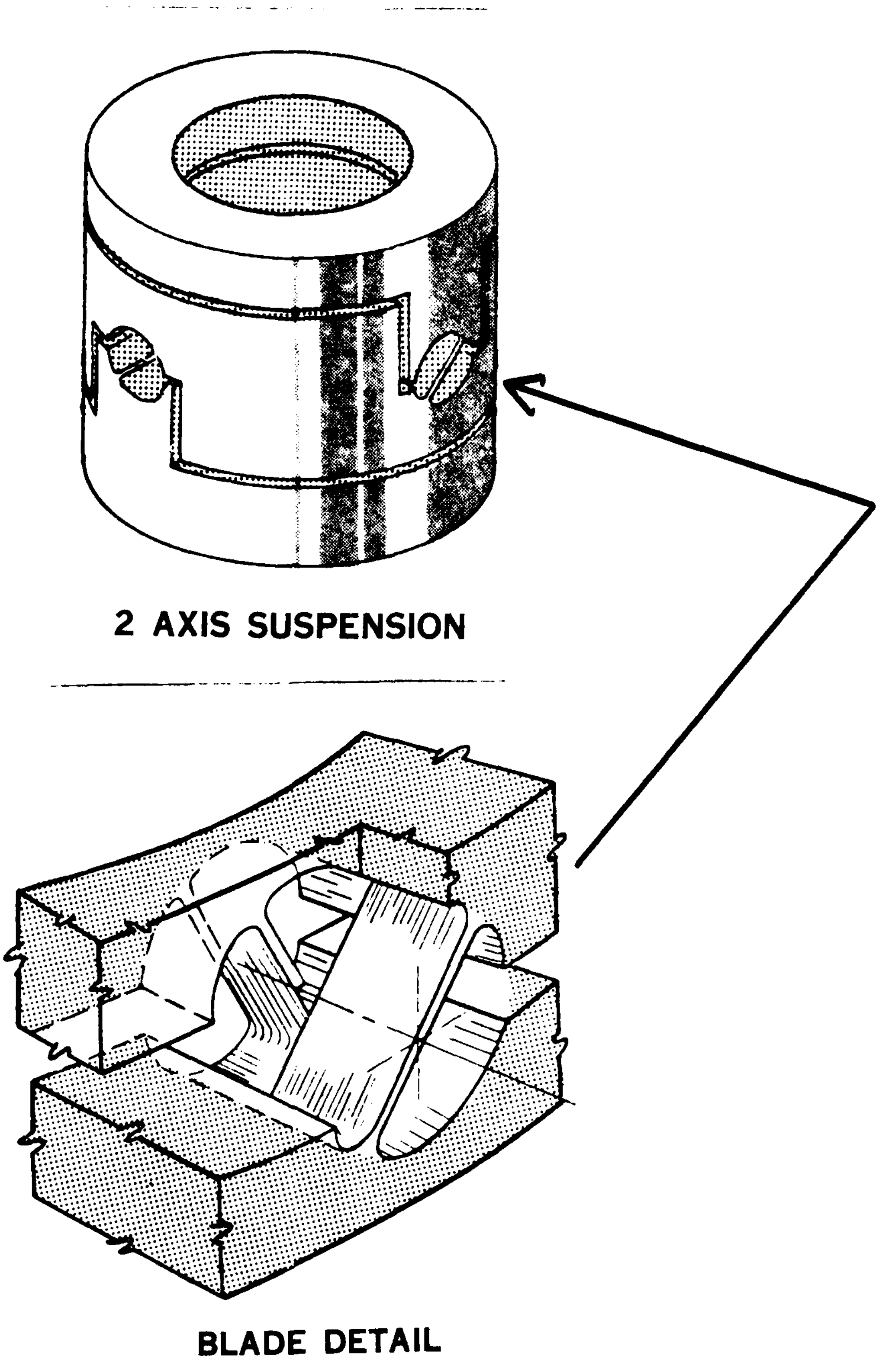


Figure 1 - Design Requirements

BENEFITS

Suspensions were, and are still available from a single outside source for $650 each (excluding the blank). Efforts to develop a second outside source were never successful. Prior to this program, in-house costs were approximately twice the cost of the outside source. As a result of this program, suspension fabrication costs have been reduced by a factor of 3.6; from $650 to $180.

IMPLEMENTATION

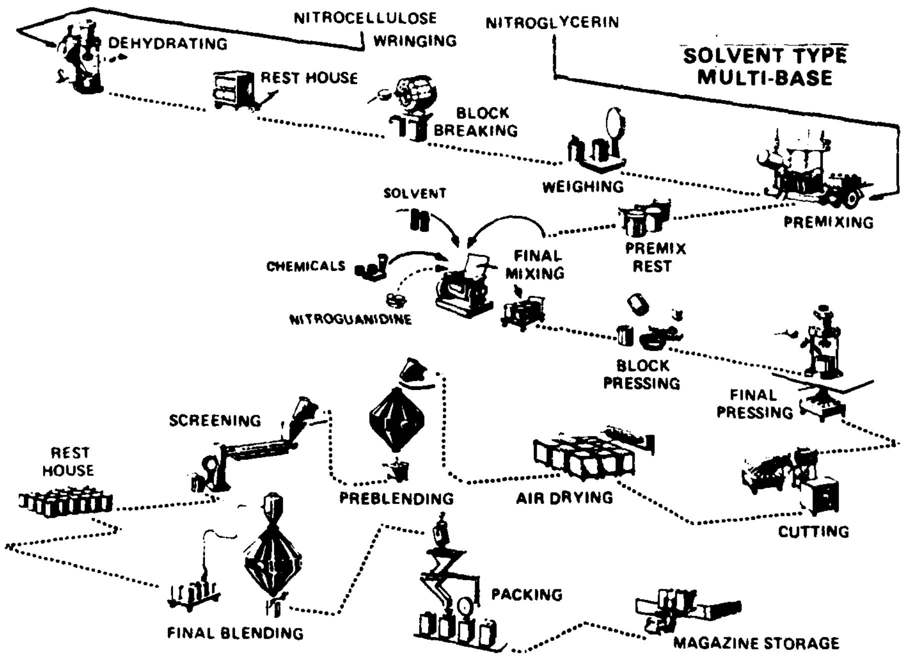
The results of this project have been implemented at Incosym, Inc.

MORE INFORMATION

Additional information and a copy of the final report is available from Mr. Lynwood Bailey, US Army Missile Command, AUTOVON 746-7582 or Commercial (205) 876-7582.

Summary report, Dec 83, was prepared by J. Sullivan, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MUNITIONS



CONVENTIONAL PROPELLANT MANUFACTURE

ABSTRACTS

The Government's loss of the sole procurement source for Pershing missile propellants TPH-8156 and TPH-8159 made the development of an alternate propellant necessary. This project designed alternate propellants M-105 and M-106, determined mixing procedures, established acceptance criteria and demonstrated processing of the propellant. The new propellant shows greater reliability and improved performance and is being used where TPH-8156 and TPH-8159 were originally specified.

Prior to this project, solvent-type, multi-base cannon propellant was manufactured using a 1940's era batch process which was both labor intensive and hazardous. This effort integrated five times of equipment into a continuous line capable of producing both double and triple base cannon propellant. This continuous process design is being constructed at Radford AAP and is expected to result in an 86 percent reduction in labor exposure to hazardous operations and a $.50/pound cut in propellant cost.

This project undertook three major improvements at Lake City AAP. The primer insert electronics were redesigned and simplified, resulting in a reduction of the number of circuit boards from four to one and lower inventory levels. A bearing analysis system was developed to monitor the acoustic emission of drive motors and some tooling and warn of impending failure. This facilitated the scheduling of maintenance during non-production hours. Equipment modifications were made to bullet and case feeders, increasing the efficiency from 83 percent to over 98 percent.

		Page
581 4558 582 4558	Thermal Dehydration Safety Analysis and Operational Redesign	MU-16

A May 1981 explosion in a nitrocellulose (NC) thermal dehydration facility caused extensive facility and equipment damage and emphasized the need for electrostatic discharge control measures and improved alcohol wetting techniques. A study of the NC thermal dehydration equipment was performed; the results indicated various possible safety measures. Among these are uniform NC cake thickness and alcohol application and purging low air flow areas with inert gas to reduce the level of O_2. These results have been incorporated into future installation design criteria.

578 6774 579 6774	Manufacturing Methods for APDS Projectile	MU-24

Production of the nylon sabot for the 25mm armor piercing discarding sabot (APDS) cartridge was considered labor intensive and unsuited to high production rates. A four-cavity mold incorporating hot runners, interchangeable die components, independent part ejection, and provisions for cleaning without press removal was fabricated to produce the sabots. The production feasibility demonstrated a machine capability of 223 parts per hour, with labor costs reduced to less than one-third of the previous level.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **377 3170** and **378 3170** both titled **"Replacement of TPH-8156 and TPH-8159 Propellant"** were completed by the US Army Missile Command in February 1979 at costs of $185,000 and $375,000, respectively.

BACKGROUND

Due to low requirements and large capital investment required to meet OSHA standards, there are no commercial sources of production for curing agents (ERL-2774 and ERL-810) used in PERSHING Stage I and II motors (Figure 1). Changing of any one ingredient requires an adjustment in the other ingredients which results in a different propellant and designation. Thus, the Government has lost the procurement source for TPH-8156 and TPH-8159 propellants. Currently deployed PERSHING propulsion units will have to be replaced in coming years and will require substitute propellants.

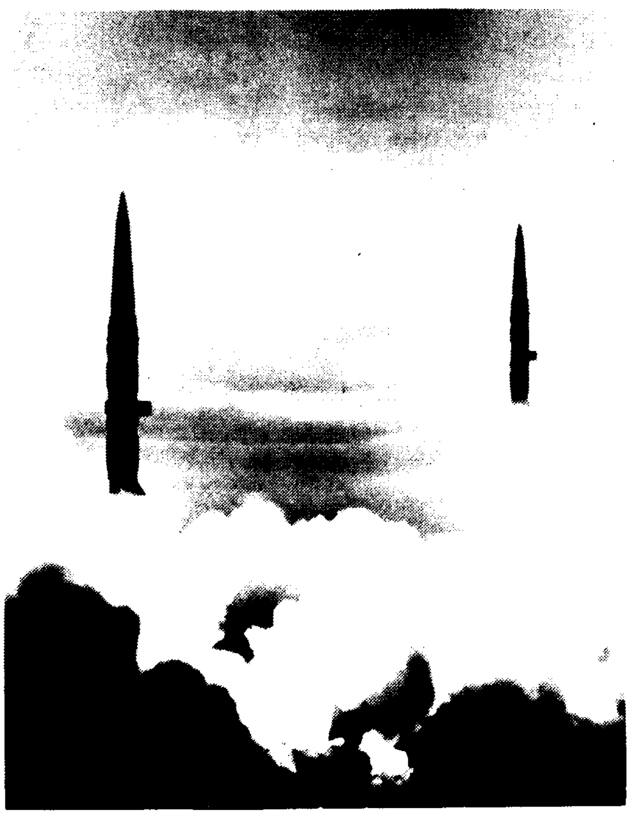


Figure 1 - Pershing Missiles

SUMMARY

The objective of these projects was to make available replacements for TPH-8156 and TPH-8159 propellants. This included determining the mixing procedures for the propellant, establishing the propellant acceptance criteria, and demonstrating that the propellant can be processed into large rocket motors.

The Longhorn Army Ammunition Plant (LAAP - a Government Owned Contractor Operated Plant) was selected to assist the Propulsion Directorate, MICOM, in this work. They had the tooling for manufacturing the demonstration motors as well as the experience in producing the TPH-8156 and TPH-8159 propellants. Longhorn is also the planned producer for the replacement propellants. PERSHING hardware was utilized for the demonstration of the propellants as they were developed and will demonstrate the propellant in mixes and motors similar to the size anticipated to be used in production.

The Propulsion Directorate, along with LAAP, successfully completed the proposed program. Mixes of the new replacement propellants, designated as MSL-302 and MSL-303, were processed in both 20 gallon and 300 gallon mixes. These propellants have been processed into the M-105 and M-106 rocket motor cases and testing of the rocket motors successfully demonstrated the propellants' acceptability. All of the processing procedures, raw material requirements and propellant acceptance test procedures have been documented.

BENEFITS

The primary benefit is the ability to produce a propellant for the PERSHING missile. A secondary benefit is that the new propellants exhibit improved performance and reliability.

IMPLEMENTATION

The replacement propellants developed, MSL-302 and MSL-303, will be used in all cases where TPH-8156 and TPH-8159 propellants were previously used or planned for future use.

MORE INFORMATION

Additional information may be obtained from Mr. William E. Thomas at MICOM, AV 746-3225 or Commercial (205) 876-3225.

Summary report, Dec 83, was prepared by Wayne Hierseman, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects 578 4150 and 579 4150 titled "**New Manufacturing Process for SAWS Ammunition**" were completed in September 1983 and March 1983, respectively, at costs of $52,000 and $375,000, respectively.

BACKGROUND

The Army's requirement for an improved performance 5.56mm round to satisfy the Squad Automatic Weapon (SAW) needs has resulted in the addition of a penetrator in the bullet design. The present production base does not have the necessary equipment for high volume loading of both the penetrator and a lead core into the 5.56mm bullet. Figure 1 shows a cross section of a conventional and penetrator type bullet.

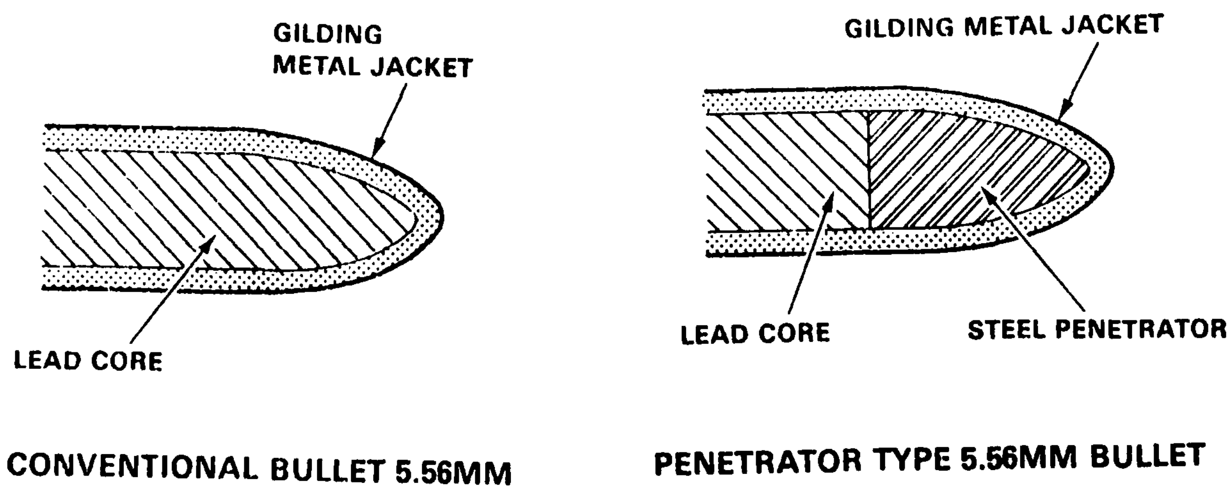


Figure 1 - Conventional and Penetrator Type Bullet

SUMMARY

The purpose of this project was to convert conventional production equipment for producing the improved performance bullet required for the SAWS weapon and to develop a method for producing the penetrator.

Two methods of producing the penetrators were investigated, skewed axis roll forming and cold heading. Roll forming is capable of a much higher production rate but handling of the finished product during subsequent operations is difficult due to burrs and surface irregularities. The cold headed penetrators, while produced at a lower rate, are currently being considered due to their relative ease of handling. A vibrating bowl type feeder with two feed tubes has been used for penetrator feeding and has performed satisfactorily when the cold headed penetrators were used.

A one draw four die stack has been used throughout this program for forming the bullet jacket. This technique has proven successful in maintaining the jacket wall thickness variations within tolerances and it will be recommended for implementation on the SCAMP bullet program.

A spring loaded punch similar to the lead seating punch was used for penetrator seating. The working end of the punch is tapered down to a 0.156 inch diameter to also allow detection of a missing penetrator. A double ended lead slug has proven to be successful for filling behind the penetrator. A pointed slug similar to the standard 5.56mm practice (M193) resulted in voids at the penetrator interface and a square slug would not feed properly. These modifications and processes for producing the SS109 type bullet were developed primarily at Lake City AAP.

BENEFITS

Production methods for the penetrator and processes and tooling for assembling the SS109 type bullet have been defined. The assembly processes are appropriate to conventional bullet manufacturing equipment.

IMPLEMENTATION

The results of these projects will be implemented and tested on a conventional ball bullet assembly machine at Lake City. Funding is provided by follow-on Project 580 4150.

ADDITIONAL INFORMATION

Additional information relating to these projects is available in a final technical report titled "New Manufacturing Process for Saws Ammunition", Contract No. DAA09-78-C-3009 or from the AMCCOM project engineer, Mr. S. Kaszupski, AUTOVON 880-4713 or Commercial (201) 724-4713.

Summary report, Dec 83, was prepared by H. Weidner, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects 573 4202, 575 4202, 576 4202, 57T 4202, and 577 4202 titled **"Prototype Equipment for the Continuous Automated Production of Solvent-Type Multi-Base Cannon Propellant"** were completed by the US Army Armament Research and Development Command in June 1980 at a total cost of $2,274,000.

BACKGROUND

When the work on this effort was begun, the method for the manufacture of solvent-type, multi-base cannon propellant was a 1940 vintage batch process. This batch process, Figure 1, was labor intensive, handled relatively large quantities of materials at each of the unit operations, exposed the operators to hazardous work environments, and required expansive land areas as safety precautions.

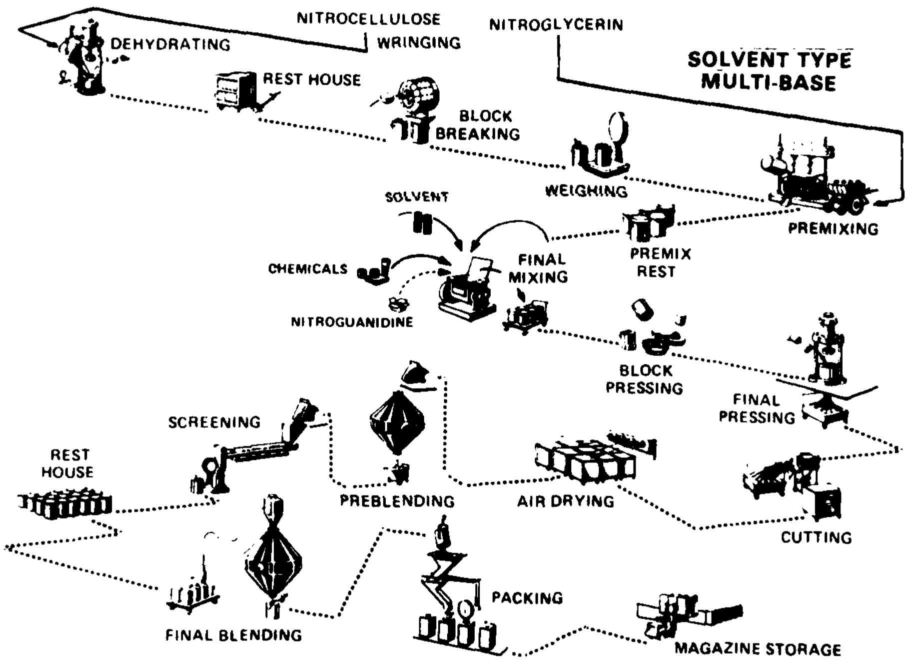


Figure 1 - Conventional Batch Propellant Manufacture

Since the 1940s, many new industrial processing techniques have been developed. It was believed that many of these processes could be applied to the manufacture of cannon propellants. The end result would be a product produced at a lower cost and a safer more modern and efficient manufacturing facility.

SUMMARY

The objective of this effort was to establish information that would provide for the design, procurement, and evaluation of an automated continuous process. To be cost effective, a facility of this design would need the flexibility to manufacture more than one type of propellant. Therefore, the prototype line built according to this design would have to be thoroughly verified by producing test lots of several types of propellants and evaluating their performance by ballistic testing.

An overall program plan was prepared and a hazards analysis and literature search were initiated. A result of the literature search was the identification of equipment that could perform, in a continuous mode, those functions that were currently being performed in a batch mode.

Specifically, there were five items of equipment that had a promising potential for application in a continuous line. A thermal dehydration unit would replace a basket centrifuge and a ram press which were used to dehydrate nitrocellulose. A continuous ribbon blender was selected to replace the batch mixing kettles. A continuous co-rotating twin screw agitator mixer was selected for the final colloiding and mixing of propellant formulations. A screw extender would replace the hydraulically driven ram press that extrudes the green propellant through graining dies to form multiple strands. The cutting of the strands would be performed by a roll cutter instead of the hand fed cutting machines. A bench scale evaluation program was established to determine the performance characteristics of this equipment. Then, a pilot line using full scale equipment was constructed. Full scale equipment was used to avoid any future scale-up problems.

Initially, the individual units of equipment were operated separately. Then the units were connected with conveyors to evaluate the system in a continuous mode. The pilot line was successfully demonstrated in August 1976. It became the basis for the facility design and equipment specifications. The facility operations will be controlled by a dedicated process controller to preclude those types of accidents that are caused by operator error. The process controller will have pre-established limits for every control loop to prevent unauthorized changes in set points to levels which may precipitate hazardous situations.

The continuous automated multi-base line (CAMBL) will be capable of producing both double base cannon propellant which contain nitrocellulose and nitroglycerin and triple base formulations of nitrocellulose, nitroglycerin, and nitroguanidine. The pilot line demonstration was accomplished by producing a triple base propellant, M30, and its performance was evaluated ballistically in the M490, 105mm tank round. Being successful, work on the pilot line was continued to broaden the knowledge of processing parameters. An additional triple base, M30A1, pilot lot was successfully tested ballistically in the M203, 155mm propelling charge. Smaller batches of double base propellant were also successfully produced for laboratory evaluation.

BENEFITS

A 56 percent reduction in the full labor force will occur upon implementation of the automated systems. A more dramatic improvement in safety will occur because of an 86 percent reduction in the direct labor exposed to the most hazardous operations. Also, safety will be improved because the quantity of material being handled at each operation will be significantly reduced. The cost of propellant produced will be reduced by approximately $0.50 per pound.

IMPLEMENTATION

The results of this effort formed the basis for the design of Facility Project 580 2875 which is being constructed at Radford AAP. The facility will be capable of producing 2.4M pounds of propellant per month. Additional facilities may be constructed at Sunflower and Badger AAP.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. L. P. Lempicki on AV 880-4123 or Commercial (201) 724-4123.

Summary report, Dec 83, was prepared by A. Kource, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project 576 4338 titled **"Development of Automated Processes and Prototype Equipment for Load Assemble and Pack of M483 Projectiles"** was completed by the US Army Armament Research and Development Command in September 1980 at a cost of $833,000.

BACKGROUND

The 155mm and 8-inch Improved Conventional Munitions (ICM) are loaded with many dual purpose grenades. The assembly and loading of these grenades into the ICMs is a labor intensive operation. Although some of the operations are automated, some of the assembly and inspection operations still need to be automated to increase production rates, improve safety to operating personnel, and allow a 100 percent self-inspecting capability.

One of the labor intensive operations in this manufacturing process is the application of tape stiffener assemblies to the grenades. The tape stiffener assemblies are procured as complete assemblies and are shipped to government plants in bulk cartons of several thousand per carton. The removal of individual tapes from the carton and their placement on the grenade's fuze is a hand operation which is slow and requires the services of many operators. If a totally automatic machine could be designed and built, many of the manual operations could be eliminated.

Another automatic machine is required to replace the manual method of separately placing each grenade, spacer, and spline into the ICM projectile bodies.

SUMMARY

The objective of this project was to develop automated equipment to reduce the manual labor requirements in two areas; namely, in the assembly of tape stiffeners and in the formation of ring packs. Two prototype machines were to be fabricated, assembled, and tested for the placement of tape assemblies onto M42/M46 grenades. One machine would have a production rate of 30 ppm; the other machine, a 90 ppm rate. A prototype was also to be designed, built, and tested to pre-pack, i.e., assemble M42/M46 grenades and their related filler hardware into a ring for continuous flow delivery of the pre-packs to the M483A1 (ICM) projectile load line.

Contracts were awarded for the development of these machines. Their performance had to be compatible with the machines that were already on line such as the "fuze to body" (FTB) machine. The standard FTB machine operated at a rate of 30 ppm but a new rotary model would have a rate of 90 ppm. In order to accommodate either of these machines, the contractor was to design and build two prototype tape stiffener assembly (TSA) machines, one for each rate of production.

Machine designs were developed, approved, and fabricated. Fabrication and assembly of the 30 ppm machine progressed slowly so the prove-out milestone was slipped. Progress on the 90 ppm machine was very slow and a cost over-run resulted. Work on this machine was halted and the funds were transferred to the 30 ppm TSA and the grenade pre-pack machine. Eventually, a cost over-run on the 30 ppm machine also occurred and additional funds had to be obtained. Finally, a demonstration test was performed at the contractor's plant. The machine failed to meet the required rate and shortly thereafter, the contact funds expired again. Subsequently, the contractor offered to make the major component of the machine workable at corporate expense. In the meantime, two auxiliary components were reworked by ARRADCOM. The 30 ppm TSA machine was then shipped to Kansas AAP where its development and prove-out would be continued under MMT project 582 4560.

The second operation that was to be automated was assembling each grenade, spacer, and spline into a circular configuration to facilitate their insertion into the M483 body. A prototype machine was to be built to automatically group one complete layer of grenades, spacers, and splines into a ring configuration which could then be inserted into the M483 as a unit.

Instead of designing a pre-pack machine for only the M483 projectile, a contract was awarded for the development of a dual purpose pre-pack machine for both the M483 and the M509 projectiles. The new dual purpose machine delayed the project somewhat but the expected benefits were considerable. Only one-half of the equipment would be required for facilitization and the dual purpose machines would be capable of operating at all existing and proposed M483 and M509 LAP facilities. The development of this machine had to be closely interfaced with the system that was being developed to inspect the grenades and insert the pre-packed grenades into the projectiles. Therefore, the continuation of this development would proceed under MMT project 579 4469.

BENEFITS

The installation of the automated machines will eliminate manual operations, improve safety, and reduce costs by approximately $2.3 million annually at FYDP production rates.

IMPLEMENTATION

The development of these machines will be continued under follow-on projects. Eventually, the automated prototype machines will be installed at Kansas AAP. Following a successful prove-out, additional machines may be purchased for Lone Star, Milan, and Mississippi AAPs.

MORE INFORMATION

Additional information may be obtained by contacting the project officer, Mr. W. Field, ARRADCOM, AV 880-4422 or (201) 724-4422.

Summary report, Dec 83, was prepared by A. Kource, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **578 4341** and **579 4341** titled "**Improved Nitrocellulose Purification Process**" were completed by the US Army Armament, Research and Development Command in September 1982 at costs of $819,900 and $846,500, respectively.

BACKGROUND

The batch purification process for nitrocellulose (NC) has remained essentially unchanged since WW II. This process takes place initially in the boiling tubs where the NC is boiled in water for periods up to 30 hours to remove any excess acid remaining in the slurry. The resultant NC slurry is then cut to a predetermined fineness in the beater house. The final purification process takes place in the poacher tub house where the NC is brought to a neutral state through another series of boils. The purification process, therefore, consumes large quantities of steam, water and electricity. A more efficient alternative for using less energy is needed.

SUMMARY

The overall objective of this effort was to develop an NC purification process which would be implemented under the Army's modernization program. Several possible approaches to this project were examined based on economics. These included modification of the existing Radford AAP purification facility alone; modification of the existing facility and one at Sunflower and Badger AAP; modification of the existing facility and 10 others located at Sunflower, Badger and Indiana AAP; updating the existing facility design to include insulation of the tubs; introduction of heat pipes to render the facility more economical; introduction of a continuous CONICELL type system in the poaching operation; and introduction of a continuous CONICELL type system for both the poaching and boiling operations. The analysis showed that the CONICELL type system for both operations was economically superior to the other approaches and, therefore, would be the approach pursued.

The CONICELL system chosen and supplied to Radford AAP by Moser Processing of Switzerland was based upon the CONICELL unit used at the Swiss Federal Powder Plant at Wimmis. This unit, as shown in Figure 1, makes use of 5 CONICELL loops and has an anticipated residence time of 45 minutes. Some unique features of this equipment are as follows:

- ° A Gitorp type heat exchanger comprised of helical spiral sheets.
- ° Viton diaphragm check valves.
- ° Special quick assembly and disassembly couplings.
- ° A 10 percent NC slurry is processed.

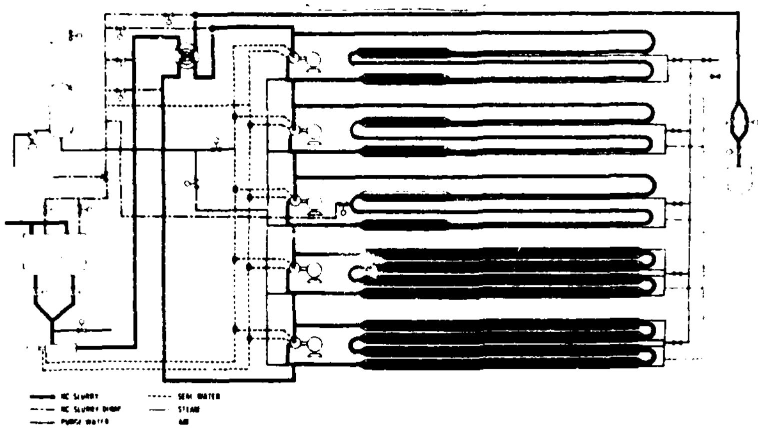


Figure 1 - Synoptic Diagram of CONICELL Process

The installation differs, however, in that a soda ash solution instead of a calcium carbonate slurry will be used to control the pH. All ancillary equipment was procured or manufactured in the United States.

Installation of the CONICELL system, along with the ancillary equipment, was completed during the FY79 project. In addition, two 24-inch Sprout Waldron attrition mills were located for use with the system. Testing of the CONICELL system will take place under the follow-on projects.

BENEFITS

This is a continuing effort and the benefits will be reported upon completion of the overall effort. Anticipated benefits, however, are reduced processing times and a reduction in energy consumption.

IMPLEMENTATION

Implementation of the results of this project are planned for Radford AAP at the completion of the overall effort.

MORE INFORMATION

To obtain additional information, contact the Project Officer, Mr. S. Lerner, AV 880-3637 or Commercial (201) 724-3637.

Summary report, Dec 83, was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **580 4411** titled **"Small Caliber Ammunition Process Improvement Program"** was completed by the US Army Armament Research and Development Command in March 1983 at a cost of $278,000.

BACKGROUND

This project was initiated to "clean up" and enhance the performance of selected portions of the SCAMP equipment at Lake City AAP. The areas selected included improvements to the case and bullet feeders, simplified primer insert electronics and the development of bearing and tool failure monitors.

SUMMARY

Primer insert electronics - The primer insert electronics were redesigned and simplified. This resulted in a reduction in the number of circuit boards from 4 to 1. Spare parts inventory and future procurement funding requirements will be reduced as a result of these simplifications.

Bearing analysis system - A breadboard system was developed to study the acoustic emissions of drive motors and some tooling. The purpose was to determine characteristics of the emissions that relate to performance degradation and impending failures so that preventive maintenance could be performed during non-production hours. The system was successful at predicting drive motor bearing failures. Predicting damage or impending failure of case submodule tooling was indecisive. This portion of the effort is being continued under Project 5XX 4164.

Bullet and Case Feeders - Improvements to the bullet and case feeders had been previously defined during the execution of Project 574 6200. This project provided for the equipment modifications and evaluation of the effectiveness of these modifications. The evaluation indicates that the feeder efficiency was increased from 85% to over 98%.

BENEFITS

The electronic components on the SCAMP primer insert submodule were reduced from 4 separate circuit boards to one. Inventory for spare parts and future procurement funds will be reduced.

Improvements to the Hoppman bullet and case feeders were demonstrated to have increased from an efficiency of 85% to over 98%.

The prototype bearing analysis system demonstrated its capability to warn the control room operator of deterioration of the main drive motors of the SCAMP case lines.

IMPLEMENTATION

These improvements were demonstrated on SCAMP lines 1 and 2. Facilities Projects 583 2201 and 583 2202 have funds delegated to incorporating the improvements into SCAMP lines 3, 4, and 5.

MORE INFORMATION

Additional information may be obtained from the AMCCOM project officer, Mr. Edward Remper, AUTOVON 880-3737 or Commercial (201) 724-3737.

Summary report, Dec 83, was prepared by H. Weidner, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects 581 4558 and 582 4558 titled **"Thermal Dehydration Safety Analysis and Operational Redesign"** were completed by the US Army Armament, Munitions and Chemical Command in June 1983 at costs of $148,000 and $430,800, respectively.

BACKGROUND

Nitrocellulose (NC) thermal dehydration is a key process in both the CASBL and CAMBL facilities. In this operation, a water-NC slurry is dried and rewetted with alcohol on an Eimco thermal dehydration unit. After rewetting, the alcohol-wet NC is conveyed to a lower level within the building and fed into plastic tubs which are then transported to propellant mix operations. On May 6, 1981, an incident occurred in an NC thermal dehydration facility causing facility and equipment damage. The most probable cause of the incident was assigned to electrostatic discharge in the vicinity of the plastic receiver. A possible contributor to the incident was incomplete wetting of the NC cake on the thermal dehydrator belt. As a result of this incident, this project was funded to obtain operational parameters and safety data.

SUMMARY

The objective of this effort was to obtain operational and safety data to determine electrostatic and operational parameters leading to in-process material ignition. To accomplish this, the automated multi-base pilot thermal dehydration equipment was reactivated and modified to perform the required tests. A schematic of the thermal dehydration operation is shown in Figure 1.

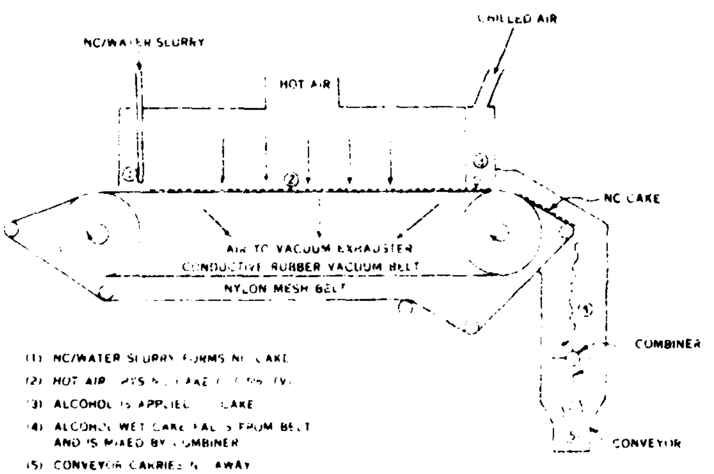


Figure 1 - Thermal Dehydration Operation Schematic

While equipment modifications were occurring, several small scale studies were conducted to provide information on cake formation and on the effectiveness of wetting the NC cake by the conventional method used in the thermal dehydration process. Results of these tests indicated that of the alternative wetting methods examined, i.e., pouring, spraying, and alcohol vapor, none were acceptable. With regard to cake formation, the following observations were made:

1. Slurry consistency (percent solids) did have some effect on cake thickness and density while applied vacuum did not.

2. Wetting the NC cake by wicking, i.e., absorption from the bottom of the cake contacting an alcohol pool, without a controlled ratio of applied alcohol to NC yields excessively wet NC cakes.

3. The use of continuous or noncontinuous vacuum application techniques makes no significant difference in alcohol penetration.

4. The high water content in the top of the cake was due to the regaining of moisture from the air.

A total of 65 runs with cotton linters NC and 9 runs with wood pulp NC were conducted using the equipment previously mentioned. Profile samples were taken of the NC cake from the filter media immediately after alcohol wetting and prior to discharge to the combiner. These samples were analyzed for alcohol and moisture content to determine the degree of alcohol saturation throughout the NC cake. Results from this analysis indicated that uniform wetting can be accomplished by assuring a uniform cake thickness on the filter media, and by uniform application of alcohol to the cake. Complete penetration of the cake by the alcohol, with minimal losses due to over-penetration, can be obtained by maintaining the required vacuum across the cake for the required time. The required vacuum and application time are a function of the material processed and cake thickness.

Measurements of the alcohol vapor and the level of static accumulation also were made. Hazardous concentrations of alcohol vapors in the alcohol spray zone were not experienced because of the continuous air flow in this region. Higher concentrations were observed in areas where little or no turnover of air existed. However, purging of these areas with an inert gas or nitrogen to an oxygen level below 9% O_2 will preclude the possibility of flame propagation by vapor phase combustion. As for the level of static accumulation, it was determined that by uniformly and thoroughly wetting the NC cake with alcohol to a minimum of 10% by weight, and by thoroughly grounding all equipment contacting the wet NC, electrostatic generation was minimized and its accumulation dissipated.

BENEFITS

The thermal dehydration of nitrocellulose is now a safer operation when the operational parameters, established as a result of this effort, are used.

IMPLEMENTATION

The recommendations resulting from this effort have been incorporated into the preliminary design criteria for future installations. In addition, these recommendations are being implemented in the existing CASBL facility and will be implemented into the CAMBL facility.

MORE INFORMATION

To obtain additional information, contact the Project Officer, Mr. C. Lewis, AV 880-3637 or Commercial (201) 724-3637.

Summary report, Dec 83, was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **575,76,7T 6494** and **577 6494** titled **"Small Caliber Process Improvement Program"** were completed by the US Army Armament Research and Development Command in September 1983 at a combined cost of $5,792,000.

BACKGROUND

The Army Modernization Program was conceived in 1967 as a result of the difficulties experienced in the reactivation and expansion of production facilities to meet the increased requirements of the Vietnam conflict. Frankford Arsenal provided recommendations on a funding concept. Lake City AAP and its operating contractor (Remington Arms Company, Incorporated) were given the responsibility of executing the majority of the concept studies relating to the modernization of production methods for Cal .50 through 30mm. To accomplish the objectives, operational criteria included: variable operating speed to 600 RPM for all calibers, automated inspection and rejection, design features to facilitate preventive maintenance and economical operation at less than rated speeds.

SUMMARY

The initial studies resulted in the selection of the rotary principle for most operations. This offers the advantages of high speed, ready access to tooling, flexibility, and ease of automating the handling procedures. The high speed to be achieved through the use of multiple tooling arranged on the periphery also increased the time allowed for a single operation. Many of the handling and tool change problems encountered in transfer presses and assembly machines are eliminated with the rotary mechanism.

The project initially addressed the manufacture of Cal .50 through 30mm ammunition but early in the program, it was decided to concentrate on the 20mm process development. After 1971, many modifications were made to the program due to funding priorities, changing requirements and a renewed interest in modernizing the private base. Work on case and projectile metal parts, fuzes, and other parts that could be procured from industry were eliminated from the program. The areas that were actually funded were high explosive incendiary charging, fuze to projectile assembly, load and assemble, ballistic acceptance testing and packing. Due to the changing requirements during the build and checkout of this equipment, none of the units were ever completed. The final changed requirement to this series of projects was the decision to competitively procure GAU-8, 25mm and 30mm ammunition from the private sector.

BENEFITS

There were no direct benefits to the government from this series of projects since none of the equipment was ever transitioned to production. The only ammunition in this series that is still being produced by the government is Cal .50; however, work on that caliber was de-emphasized early in the program in favor of the other rounds. There were several technical accomplishments made during the performance of these projects that may have future applications.

IMPLEMENTATION

There are currently no plans to implement the results of these projects.

MORE INFORMATION

Additional information relating to this series of projects are contained in a technical report titled "New Concepts for Manufacture and Inspection of 20mm, 25mm and 30mm Ammunition", dated February 1982, Accession No. ADE400787, or may be obtained from the AMCCOM project engineer, Mr. William Dittrich, AUTOVON 880-6292 or Commercial (201) 724-6292.

Summary report, Dec 83, was prepared by H. Weidner, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects 575 6596, 576 6596, 577 6596 and 578 6596 titled "Ball Propellant Pilot Plant Studies" were completed by the US Army Research and Development Command in July 1982 at costs of $1,069,000, $1,230,000, $1,095,000 and $1,538,000, respectively.

BACKGROUND

The Army's policy had been to rely on the commercial sector for new ball propellant developments. However, plans to modernize the Badger Army Ammunition Plant's (BAAP) ball propellant facilities required the Army to change this policy. Hence, it was decided to establish a pilot plant facility in which more modern, cost effective processes would be evaluated.

SUMMARY

The objectives of this effort were to; (a) establish a flexible pilot plant, (b) perform the essential process engineering of prototypes for ball propellant modernization, (c) provide a base for process improvement in support of current and future production, and (d) develop design data for each step evaluated.

To make more efficient use of available funds, it was decided to use space in the existing Ball Propellant Auxiliary Line complex at BAAP. It has a basic 1000-gallon still. Similarly, as much of the existing auxiliary line equipment as possible was retained. Equipment representing the latest technology was purchased. Hazards analysis was conducted throughout the project to insure compliance with applicable regulations.

Besides the modified 1,000-gallon still, 10- and 100-gallon stills scaled down from the regular plant 5,000-gallon still were designed, fabricated and installed. (See Figures 1 and 2).

A continuous graining line with an automatic control system and separate computer for data collection, display and processing was also designed, purchased and installed. The addition of a steam plant and air supply system made the pilot plant independent of plant services, thereby allowing for more economical operation.

This modern ball propellant pilot plant allows the use of all the past, present and identifiable future manufacturing steps. Extensive control and recording facilities are available as part of this installation. This enables productivity analysis studies to be made for the optimum selection of process combination modes and equipment options over a large range of production levels and mixes.

Figure 1 - 10 Gallon Batch Still System

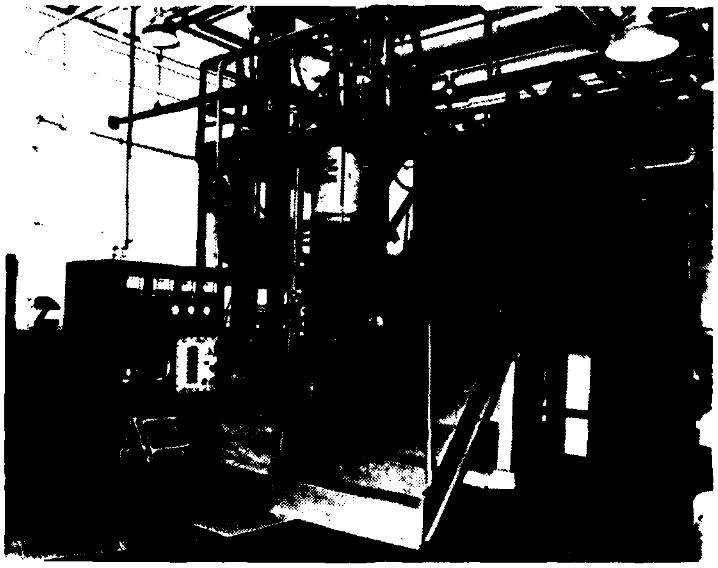


Figure 2 - 100 Gallon Batch Still System

Once the equipment was installed, a planned series of tests was begun. Equipment was debugged and data gathered and compared with full plant operation. Results show good correlation for cycle time, maximum still load, effects of material changes, procedure changes, and gross changes in yields. For the hardening operation, more than five tests are required to quantitatively detect sufficiently reproducible yield changes.

The use of external lacquer was shown to be technically feasible. Sufficient information was developed to allow the design of an external lacquer system using nitropulp containing 30, 50 or 75 percent water.

BENEFITS

In addition to establishing the most optimum design for the modernization program, the pilot plant can be used for developing further improvements in the existing production ball propellant facilities. It can also be used for: (1) developing new propellants and investigating problems with existing propellants; (2) wastewater and recovery studies for ball propellant facilities; (3) characterizing, mixing, transferring and extruding a wide variety of viscous, non-Newtonian fluids; (4) reactors to manufacture pilot lots of chemicals over a wide range of batch sizes; (5) evaluating equipment used for chemical processing, pollution control equipment; and (6) investigating safer and more economical methods of manufacturing extruded propellants by use of modern ball propellant technology.

IMPLEMENTATION

The modernization of BAAP ball propellant facilities is now planned for the 1990's. Hence, there is no immediate plan for implementation. However, the process studies performed during this effort show that with a very modest investment in the production line, a 17 percent increase in process capacity could be obtained. Increasingly higher investments could result in up to a 78 percent increase in ball propellant capacity. The studies indicated that only additional equipment, not buildings, would be required to attain these increases.

MORE INFORMATION

Additional information on this effort can be obtained from Mr. Robert M. Pizzola, ARRADCOM, AV 880-4512 or Commercial (201) 328-4512. Also, the following Technical Reports have been published:

Volume I - Ball Propellant Pilot Plant Studies - Sept 1981*
Volume II " " " " " " " *
Volume III - " " " " " " " *
ARSCD-CR-82025 - Scaling of 100-Gallon Still - Oct 1982

* All published for BAAP by Olin Winchester Group Powder Operators

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Summary report, Dec 83, was prepared by Wayne Hierseman, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

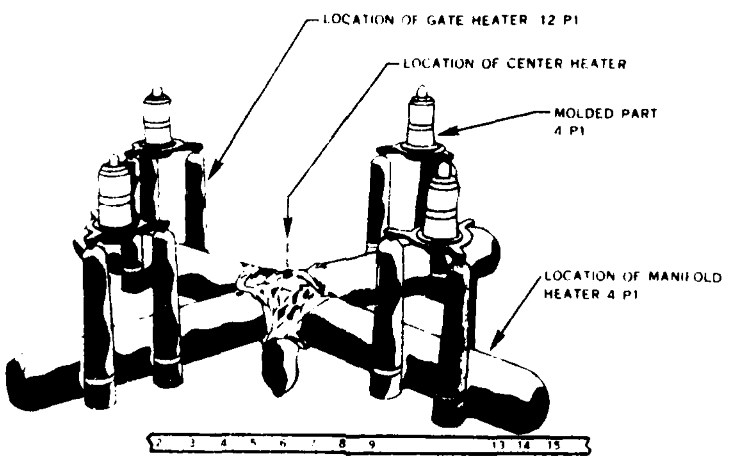
MMT Projects **578 6774** and **579 6774** titled **"Manufacturing Methods for APDS Projectile"** were completed by the US Army Armament, Munitions and Chemical Command in March 1983 at costs of $300,000 and $895,000 respectively.

BACKGROUND

A manufacturing problem was anticipated in producing the nylon sabot for the 25mm armor piercing discarding sabot (APDS) cartridge. The current method for producing the R&D rounds was labor intensive and not suitable for high production rates.

SUMMARY

This project established the processes, supporting equipment, tooling and production layout for the manufacture of 25mm APDS (M791) projectile subassemblies including the plastic sabot and metal/plastic parts. An economical production capacity of 75,000 units/month with a reserve mobilization capacity of expansion to 200,000 units/month was established. The most significant achievement was the four cavity mold for producing the discarding sabot. The mold is capable of producing four units at a time on a fifty second cycle. Other pertinent characteristics of the machine include: hot runners, interchangeable die components, independent part ejection, no part-no mold interlock and provisions for mold cleaning without removal from the press.



Nylon Casting of Hot Runner System

The complete system was shipped to Ford Aerospace in September 1980 for system integration and functional testing. The first functional test consisted of approximately 3000 units, however, problems were experienced with oil leaks, part sensing switches and thermocouples. The oil leaks, sensing switch and other minor problems were either corrected or design changes were initiated that subsequently corrected the problems. The thermocouple problem was not thoroughly resolved although improvements were made.

A production feasibility demonstration was conducted to assure that the equipment would meet the production rate objective of 75,000 units/month (one shift) with a reserve capability of 200,000 units/month (3 shift operation). Three separate "shifts" of operation were run with an average operating rate of 223 parts per hour being attained. Several thermocouple failures occurred during this demonstration reaffirming that the previously experienced problems were not corrected. The production rate of this machine would be enhanced with a correction to this problem, however, the experienced rate does meet requirements. Ballistic testing of a sample of the rounds indicated satisfactory performance.

BENEFITS

The process, support equipment, tooling, and facility layout required to produce 75,000 APDS projectiles per month has been completed. The four cavity molding system and the trim machine can be assigned for immediate production. Unit labor costs will be less than a third of that required for single cavity operations.

IMPLEMENTATION

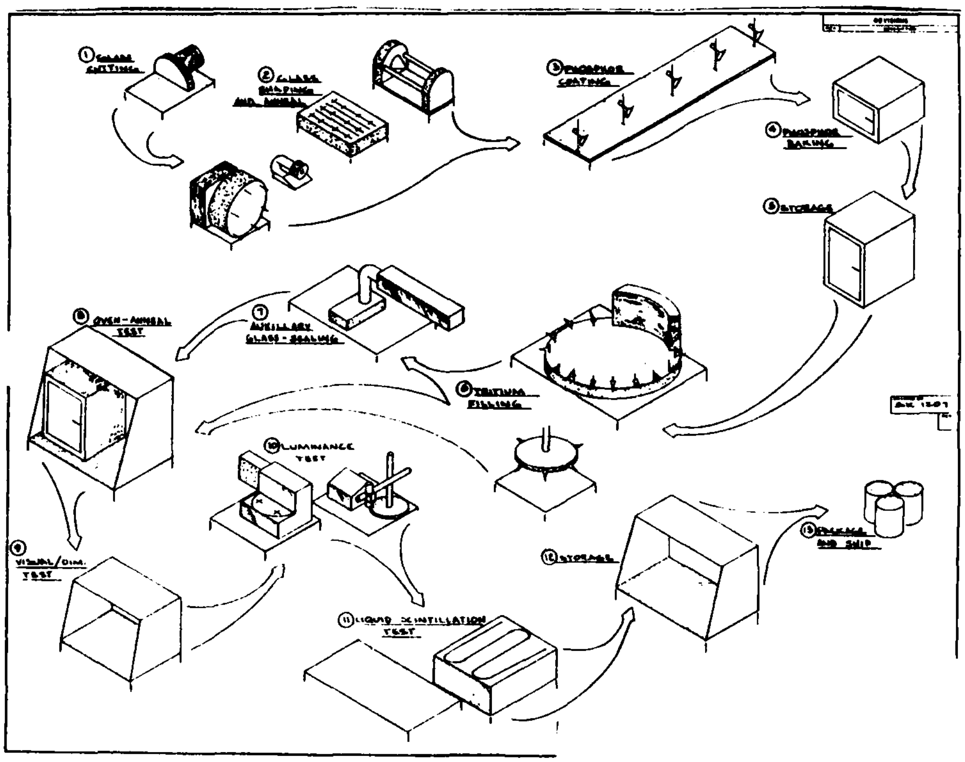
A proposal was submitted to TACOM showing the overall positive impact of incorporating the MMT equipment into the APDS line (contract DAAK30-80-C-0010). Subsequent contract negotiations resulted in a $235,000 cost reduction for 903,000 cartridges still to be delivered on that contract.

MORE INFORMATION

Additional information on this injection and trimming system may be obtained from Mr. Joseph McCormick, AUTOVON 880-3737 or (201) 328-3737.

Summary report, Dec 83, was prepared by H. Weidner, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

NON-METALS



SELF-LUMINOUS LIGHT SOURCE PROCESS

ABSTRACTS

This effort had the dual goals of evaluating existing production techniques for military gas filters and studying physiological and environmental effects of manufacturing impregnated charcoal. A method of measuring filter performance by recording air flow velocity through the filter was developed and will be made available to filter producers. Health hazards associated with metallic copper, silver and chromium (by products of charcoal impregnation) were identified for further pollution abatement studies.

A wide variety of components combine to form a biological detector and warning system. This effort established manufacturing processes necessary to produce these components. A tape coating and reel winding machine applies a rubber-based adhesive to a polyester film substrate ribbon. Equipment to make syringe-type pump injector assemblies and chemical reaction cell assembly was also designed and built. These improvements resulted in a cost reduction from $21 to $8 per tape/reel assembly, as well as greater reliability and maintainability.

Production of TNT results in red water, a waste product which has been classified as hazardous by the EPA. This project developed design data to implement the Socono Sulfite Recovery Process (SSRP - developed in an earlier project) to recycle red water. A new multiple hearth furnace was evaluated and other equipment/operating requirements were established. The resulting SSRP can reclaim sodium sulfite used in the manufacturing process and will be used in the new TNT production system being constructed at Radford AAP.

		Page
581 4288	Explosive Safe Separation and Sensitivity Criteria	N-13

This effort to develop new safety criteria for explosive facilities deals with the safe separation distances for 30mm M789 HEDP projectiles, 25mm M792 HEI-T cartridges, and M74AP/M75 AT-AV mines. Exploratory and confirmatory tested was done for various configurations of each explosive. The results were integrated into safety regulatory documents and applied at Twin Cities AAP and Ford Aerospace.

581 4298	Evaluation of DMN Disposal on Holston AAP B-Line	N-16

Dimethylnitrosamine (DMN), a potent carcinogen listed as toxic by the EPA, is produced by the ammonia and acetic acid recovery processes at Holston AAP. Two methods of treatment for abatement of the DMN were evaluated. The most practical was determined to be the catalytic hydrogenation of the final sludge produced during regular production. These results will be implemented at Holston to eliminate downstream treatment of water and to comply with EPA regulations.

580 4309	Process for Molding Rear Seal, 120mm APDS	N-19

An adaption of the process for molding rubber rear seals in various projectiles was needed to reduce manual labor and allow for mass production. Alternate seal materials and bonding techniques were analyzed. Silicon rubber and Dow Corning adhesive 96-086 were selected and the completed assemblies were tested using interior ballistic and dispersion tests. The resulting seal demonstrated equal or superior performance in all functional tests and is less expensive than the older process.

		Page
576 4337	Investigation of Alternate Materials and Methods for Curing and Molding Processes for Encapsulating Material for ADAM (Area Denial Artillery Munition) Mines M67/M72	N-22

Long curing times and a low maximum curing temperature for ADAM mines leads to high production costs. This project consisted of three separate phases: Phase I evaluated the effect of using ATC-3 accelerator on the cure time of the mine housing; Phase II studied the effect of ultraviolet radiation on cure time; Phase III developed mechanical and in-situ techniques to join the mine body to the housing. Phase III yielded two feasible attachment methods, and indicated a possible cost reduction from $11.83 to $3.00 per assembly of in-situ bonding if implemented.

E79 3743 E81 3743	Composite Spun Material Traversing Beam for Bridges	N-30

Conventional metallic beams used in assault bridges are costly, heavy, and exhibit large deflections. This effort established the manufacturing technology to produce graphite epoxy beam components. Filaments were wrapped around a 25 foot mandrel to form bridge bottom chord sandwich panels and one modular composite traversing beam. The resultant sections were 25 percent lighter and 250 percent stronger than previous metallic parts.

R81 1026	Production of Low Cost Missile Vanes	N-38

Control vanes, fins, and external rocket and missile fairings are generally cast and forged, resulting in expensive, heavy, long lead time parts. This project developed automated production techniques to fabricate Pershing missile vanes from high temperature, fiber composites. The resultant composite air vane was lighter and required significantly less labor and material than the cost vane. The net molding and concurring techniques developed by this project are also applicable to other missile systems.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **579 1296** and **580 1296** titled **"Manufacturing Technology for Chemical Biological Filters"** were completed by the US Army Armament, Research and Development Command in March 1983 at a cost of $400,000 and $404,000, respectively.

BACKGROUND

These projects are a continuation of a multi-year effort to develop and establish state-of-the-art production base techniques for military gas filters. In addition, an increased emphasis on quality control coupled with increased labor and testing costs have resulted in the need for more effective manufacturing operations and filter performance evaluation. The prior year's efforts (FY76, FY78) consisted of the evaluation and development of more effective charcoal handling and filling equipment.

These projects emphasized the completion of the remaining tasks under this overall effort.

SUMMARY

The general objective of these projects was to analyze the current processes used in filter production, develop process data, process baselines and manufacturing methods which would lead to a more effective production base. The effort was divided into 5 tasks: (a) charcoal handling, (b) filling operations, (c) process evaluation and control, (d) dust and moisture control, and (e) charcoal impregnation. The following paragraphs provide discussion of tasks (c) and (e). Tasks (a), (b) and (d) were completed and summarized under prior year's projects.

Process Evaluation and Control

The purpose of this task was to determine how charcoal filter performance was affected by changes in manufacturing process variables. Initially, a number of testing techniques for measuring the effects of process variables were identified and experimentally evaluated. The two most promising techniques identified were the velocity traverse (VT) and laser-induced fluorescence (LIF) methods. The VT method measured the velocity of the airstream at points on the filter exit. The LIF method measured the fluorescence intensity distribution of an adsorbable gas emerging from the filter. Both methods were successfully demonstrated on small scale filters. However, since the VT method was more advanced in development than the LIF method, it was selected for scale-up to larger filters. The VT technique, as stated earlier, measured and mapped the velocity of air passing through the filter on a prescribed grid. The air velocity was measured by a hot wire anemometer. The resultant readings of the x-y traverse was plotted on a x-y-z grid which provided a visual indication of the velocity profile of the air passing through the filter cell. A typical velocity map of the center section of an Army C-10 Collective Protection Filter is shown in Figure 1.

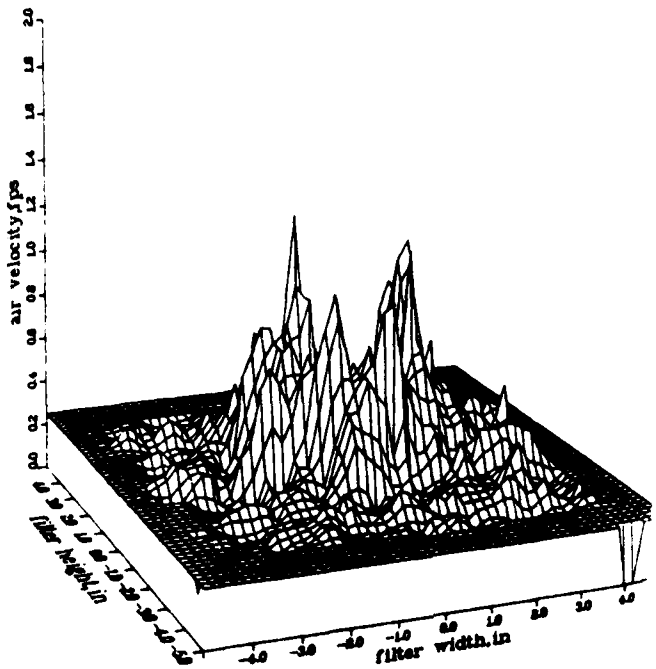


Figure 1 - Velocity Map of the Center Section of an Army C-10 Collective Protection Filter With Edge Effect Eliminated

Air velocity profiles were made using both face and edge filled (approximately 1'x 1' x 1-1/8") charcoal filters. The VT technique identified areas of high velocity which were flaws of rapid penetration of gases. These areas also indicated flaws in the filter either because of design or production practices. The VT technique can determine if poor filter construction allows channeling along the edges to occur. It will also indicate if a bad filling technique results in a density gradient along the length of the filter. Thus the VT is a tool which, when made available to filter producers, can help them resolve production problems and indicate the reasons for filter failure.

Charcoal Impregnation

This task involved study of the physiological and environmental effects which may result from the manufacture of impregnated charcoal. The studies included the health hazards from exposure to metallic copper, silver and chromium. Results indicated that there was no evidence that airborne metallic silver and copper resulted in any human disease. However, hexavalent chromium is carcinogenic. The National Institute for Occupational Safety and Health recommends a maximum concentration of 1 ug/m^3 of airborne hexavalent chromium. Silver, copper and chromium were all found to be toxic to aquatic life. In addition, bioconcentration of chromium occurs in aquatic organisms, thus the release of chromium into the water should be avoided. A suggested means of disposal was to reduce the hexavalent chromium to the less dangerous trivalent state by the addition of lime. Silver could be recovered by leaching and subsequent precipitation.

BENEFITS

A velocity traverse method was developed which can be used to evaluate charcoal filter performance and design. The health hazards associated with the manufacture of impregnated charcoal were identified for pollution abatement studies.

IMPLEMENTATION

The filter fabrication technology developed was made available in technical reports to filter manufacturers as advisory information.

MORE INFORMATION

Additional information can be obtained by contacting Mr. T. Sowis, AMCCOM, AV 584-4351 or Commercial (301) 671-4351.

Summary report, Dec 83, was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects 579 1345 and 580 1345 titled **"Manufacturing Technology for Biological Detection and Warning System (BDWS)"** were completed by the US Army Armament Research and Development Command in January 1983 at a cost of $525,000 and $463,000, respectively.

BACKGROUND

This project is a continuation of an effort to develop a biological detector and warning station (BDWS). The station was composed of two major subsystems, the XM19 alarm which continuously monitors the air and detects by chemiluminescent reaction, and the XM2 sampler which collects samples from the air once the presence of biological material has been detected by the XM19 alarm. The BDWS contained several components for which manufacturing specifications, tolerances, and process data are not currently available. An essential component of the system is an impaction tape for the collection of particles which may be biological. The FY78 project developed the method for tape coating and determined the process variables and parameters for tape coating.

In addition to the tape coating development, manufacturing processes needed to be established for the remaining BDWS components to assure their producibility.

SUMMARY

The investigation was conducted for the purpose of obtaining manufacturing data, establishing a process and documenting the manufacturing process with a description of manufacture (DOM) for selected assemblies, subassemblies and components of the BDWS. Principle studies were performed on the tape/reel assembly, injector and cell assemblies. The assemblies studied were major components of the XM19 Alarm.

The XM19 alarm sampled air through a 2-stage collector/concentrator. The air from the concentrator impacted on a continuously moving coated tape to which the particles adhered. A stream of water was used to wash off the particles. The water sample and reagent were injected into a reaction cell. In the cell, the light emmission was monitored. When biological organisms were present, an alarm produced both visible and audible signals.

The following paragraphs describe the results of the investigation for the various assemblies:

Tape and Reel

The tape consisted of a polyester film substrate coated with a natural rubber-based adhesive which was assembled onto a special reel. The tape and reel assembly equipment was not commercially available because of a low volume production requirement and proprietary process information. The main objective of this study was to establish a tape manufacturing pilot facility.

The pilot facility constructed consisted of coating, drying, curing, slitting/winding stations and associated control equipment. Improvements were made to the equipment to assure product uniformity. These improvements consisted of modifications to the winding station to provide precise winding on the reels, and provide uniform process speed and web tension. A schematic process diagram showing the principal operations in the tape manufacturing process is given in Figure 1.

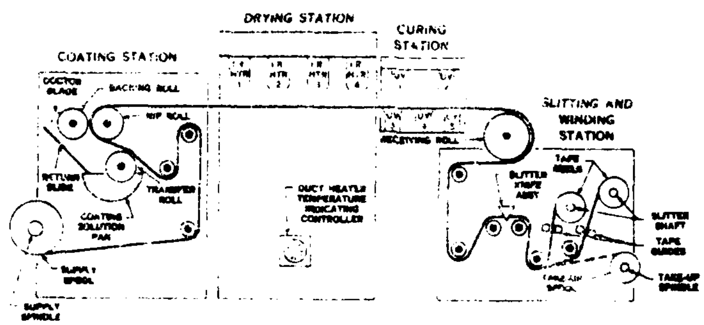


Figure 1 - BDWS Tape Manufacturing Process

The milling and mixing equipment for preparation of the coating solution are not shown in the figure. A thin coating of adhesive was applied to the substrate at the coating station by the transfer roll. The excess adhesive was removed by a doctor blade and returned to the coating solution pan by the return slide. The tape then passed through the drying station composed of four infrared heater units. The tape was then cured utilizing five ultraviolet lamps in order to cause crosslinking for a good bond between the coating and the substrate. The final station was composed of slitter knives which cut the tape prior to winding onto a reel.

After operating personnel had gained considerable experience with the pilot equipment, a DOM was prepared by observing the operators and recording every operation, all materials, tools and equipment used.

Injector Assembly

The injector assembly consisted of a dual syringe-type pump which injected equal volumes of the water sample and reagent into a reaction cell. Studies were accomplished on the existing assembly procedures, manufacturing methods and materials. From these studies, components were fabricated using the selected methods and materials. Injection molding was utilized to produce the injector pump and components from polycarbonate. This increased the reliability and maintainability of the assembly. In addition, assembly procedures were modified and all manufacturing and material changes were implemented into the TDP.

Cell Assembly

A chemical reaction took place between the premix solution and the sample solution in the cell assembly. The reaction emitted light which was sensed by a photomultiplier. The existing cell assembly procedures were studied and recommended changes were made. Based on these studies, approximately 50 changes were made to the cell assembly and a DOM was prepared to clarify assembly operations.

BENEFITS

The manufacturing methods and materials for the tape/reel assembly and other critical components (injector pump, cell) for the BDWS were established. The cost of the tape/reel assembly was reduced from $21 to $8 per unit. The reliability and maintainability of the assemblies were increased.

IMPLEMENTATION

The tape pilot facility equipment is available for use as initial production equipment to a producer. A description of manufacture (DOM) and manufacturing data have been incorporated into the TDP for the tape/reel assembly and other components.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. T. Gervasoni, AV 584-4250 or commercial (301) 671-4250.

Summary report, Dec 83, was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **579 4225, 580 4225,** and **581 4225** titled **"Red Water Pollution Abatement System"** were completed by the US Army Armament, Munitions and Chemical Command in September 1983 at costs of $349,348, $152,522, and $157,733, respectively.

BACKGROUND

Since World War I, trinitrotoluene (TNT) manufactured in the US has been purified using the Sellite process. Sellite (sodium sulfite) reacts preferentially with the isomers of TNT to produce sulfonates, other complexes, and various oxidation products. This solution is commonly referred to as red water. Red water is classified as a hazardous waste by the EPA and, therefore, must be handled and disposed of in a manner to prevent pollution of the environment. Initially, disposal of red water at TNT plants was by incineration followed by landfilling of the ash. However, the ash produced a leachate due to incomplete burning of some compounds and the carbon produced precluded its use for normal commercial purposes. Therefore, a process was needed which would allow the red water to be recycled and protect the environment.

In September 1977, a production engineering project PE-607 was established at Radford AAP to provide laboratory support to a Volunteer AAP project to develop a means of recycling red water. This effort eventually led to the selection of the Sonoco Sulfite Recovery Process (SSRP) as the most viable method. Further testing at Volunteer AAP led to a decision to investigate the use of a multiple hearth furnace as the thermal reactor to replace the rotary kiln used in the SSRP. In addition, Volunteer's TNT production operations were terminated thereby leaving Radford AAP as the Army's warm-base TNT production facility. A project was then initiated to provide the developmental efforts necessary to abate red water.

SUMMARY

The main objective of this project was to develop design data for implementing the SSRP for disposal of red water and recovery of sodium sulfite at Army Ammunition Plants. The approach was to evaluate the multiple hearth furnace and establish equipment/operating requirements for all components of the process. This was accomplished by performing pilot tests at other contractor plants and Radford AAP.

The proposed schematic for intended use of the SSRP is shown in Figure 1.

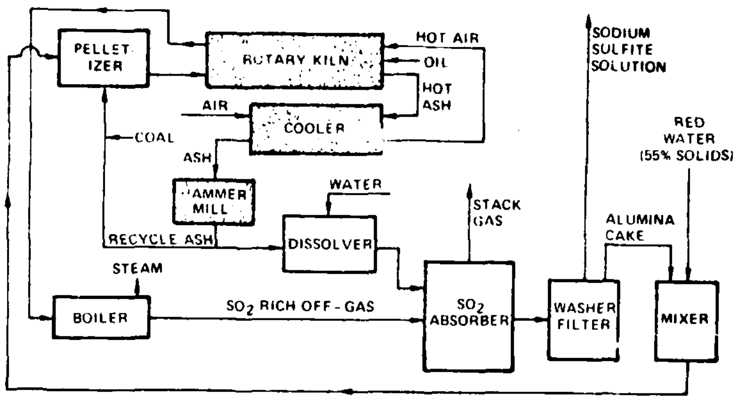


Figure 1 - Sonoco Sulfite Recovery Process

Concentrated red water (55% solids) was fed into a rotary disc pelletizer along with a supplemental fuel, alumina cake and recycle ash. The pellets formed were then reacted in a rotary kiln where the sulfur containing compounds were changed to sodium aluminate ash while the sulfur was released as H_2S gas. The H_2S gas was then converted to SO_2 in the slightly oxidizing atmosphere outside the pellets and while still within the kiln. After cooling and sizing, product ash was dissolved in water and the thin slurry solution was subsequently used as the scrubbing media in the SO_2 absorption tower. Here, cooled SO_2 from the kiln was introduced counter-currently at the bottom of the tower. The resultant thick slurry was processed through a washing/filtration stage to yield sodium sulfite solution and alumina cake. The alumina was recycled as described previously while the sodium sulfite solution was returned to the TNT purification area.

Initially, pilot scale incineration tests were performed with a multiple hearth furnace. The main objective of these tests was to obtain empirical data that was used to design a large scale furnace. Other objectives were to obtain samples and/or measurements that enabled the design of dust collectors and scrubbers and to provide a better understanding of the thermo-chemical reactions.

Analysis of the data from the multiple hearth tests revealed that it is adequate for converting TNT red water into compounds that will recombine in a SO_2 absorber to form Sellite. It was found to be superior to the rotary kiln equipment. Other conclusions drawn from these tests show that the average temperature required in the hot zone of the furnace for the most efficient conversion of red water was 950°C (1750°F). The size of the furnace to be used at Radford AAP was calculated to require $118.3 m^2$ ($1273 ft^2$) of hearth area (8 hearths).

The production of NOX from the furnace was at an acceptable level and the level of particulates produced was not considered a problem. However, H_2S was produced in the discharge gas stream so an afterburner would be required.

Further studies indicated that the feedstock preparation and feeding system used in the SSRP was not satisfactory for the red water treatment. This was due to the fire hazard of the dry red water solids and the dusting during pelletizing. Therefore, a system was designed to start with 15 percent solid red water, extract some water, add carbon plus the alkaline furnace ash, mix, and then insert the wet paste into the furnace.

The principle pieces of equipment for feedstock preparation and furnace feeding system were pilot tested. These studies/tests involved 6 generic types of red water concentrators, 4 mixers, 3 types of pumps, and 2 screw conveyors. The feed train system, which was finally selected, consisted of a multiple-effects evaporator, a direct contact evaporator, 2 hollow-shaft evaporators, 2 pug mill mixers, and 2 constant-OD-auger screw conveyors.

Based on a 100 tons/day production of TNT, a mass and energy balance for the process was prepared. In addition, a project development brochure was prepared to be used as design criteria for the facility.

BENEFITS

Chemical recovery technology, based on the SSRP, was developed for the treatment of red water from TNT production. In addition, the sellite would be reclaimed and recycled.

IMPLEMENTATION

The information and data from this project will be used to design a sulfite recovery process to be constructed at Radford AAP (FY85 MCA project).

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. J. Swotinsky, AMCOM, AV 880-4284 or Commercial (201) 328-4284.

Summary report, Dec 83, was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **581 4288** titled "**Explosive Safe Separation and Sensitivity Criteria**" was completed by the US Army Armament, Munitions and Chemical Command in July 1983 at a cost of $620,000.

BACKGROUND

This project is a continuation of a multi-year effort to develop safety criteria that can be used as a basis for the design of all future explosive production facilities. At the present time, an Army-wide modernization program is underway to either upgrade existing or develop new explosive manufacturing and load-assembly-pack (LAP) facilities. This effort will enable the US Army to achieve increased cost effectiveness and improved safety, as well as provide manufacturing facilities for new weaponry with existing facilities. The prior year's effort consisted of studies to determine the safe separation of explosives and items such as 8-inch M509HE projectiles, 105mm HEAT-T cartridges M456, M55 stab detonators, and small arms propellants.

The effort described here emphasized studies in safe separation distances for 30mm M789 HEDP projectiles, 25mm M792 HEI-T cartridges, and M74AP/M75 AT-AV mines.

SUMMARY

The objectives of this program were to establish the safe separation (nonpropagation) distance criteria for munition end items and subcomponents. The following paragraphs provide examples of work accomplished on specific items:

30mm M789 HEDP Projectiles

This test program was to determine, experimentally, the minimum safe separation distances for 6 component configurations of the 30mm M789 HEDP projectile to be utilized at the Twin Cities Army Ammunition Plant. Two phases of testing, exploratory and confirmatory, were accomplished to establish the minimum non-propagatory distances between various components.

The first hardware configuration consisted of two 13.5 gram hollow core PBXN-5 pellets stacked vertically on top of the other. The second consisted of vertically positioned 30mm shell bodies each containing 2 loosely fitted PBXN-5 pellets. The third consisted of the 30mm HEDP loaded body which included the shell body, charge liner, retaining ring, and a PBXN-5 booster charge. The fourth consisted of the same loaded body assembly as the third configuration, but it was heated to an internal temperature of 96°C (205°F) prior to initiation. The fifth consisted of a complete projectile with a fuze. The sixth consisted of a fuzed projectile heated to an internal temperature of 96°C (205°F).

The results of the tests showed that the non-propagating distance was 25.4mm (1.0 inch) at 6-7 percent probability for configurations 1 through 3. The safe separation distance for configurations 4 and 5 was determined to be 76.2mm (3.0 inches) with a 7 and 6 percent probability respectively. The sixth configuration resulted in no safe separation distance established.

25mm XM792 HEI-T Cartridges

The purpose of this program was to determine the safe separation distance between units on the conveying system, conveyor speeds, and the rate of production of 25mm tank cartridges. The test program consisted of 5 phases, each corresponding to component or cartridge assembly locations on the overall assembly line of the cartridge. These locations were (1) between one of the prepelleting stations and the HEI charging station, a vertical stack of 3 type I pellets (3.35 grams), (2) a single type II pellet (1.94 grams) between a prepelleting station and the HEI charging station, (3) a vertical loaded body assembly containing 30.2 grams of HEI mix between the body charging station and the projectile fuzing station, (4) a vertically oriented projectile fuzed between the projectile fuzing station and the cartridge case station, and (5) a complete cartridge vertically oriented between the cartridge case station and the packout operation.

The minimum nonpropagation distance for vertical stacks, each containing 3 type I explosive pellets, was 25.4mm (1.0 in.), and 12.7mm (0.5 in) for the single type II pellets. The minimum nonpropagation distances for loaded body assemblies, fuzed projectiles, and complete cartridges were all 63.5mm (2.5 in).

M74AP and M75AT-AV Mines

The objective of this project was to determine the safe spacing between mines situated individually along a standard conveyor system so that the effects of an accidental detonation would be limited and not propagate to adjacent areas.

Each test layout consisted of one donor and two acceptor mines arrayed in a straight line and raised off the ground to simulate the conveyor system's average stand-off distance above the building floor, as shown in Figure 1. The center specimen served as the donor, or initiated mine, while the mines on either side served as the acceptor specimens, thus producing two acceptor sets of test data results for each test donor detonated. During the exploratory test phase, the test separation distance between the donor and acceptor mines was varied from test to test, and also within the single test firings. However, during the confirmation test phase, the donor-to-acceptor separation distance was held constant at all times.

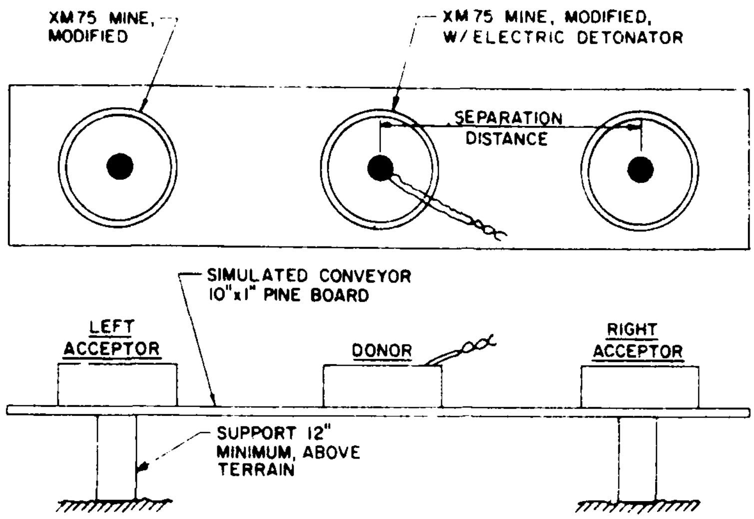


Figure 1 - Test Array, Unbarricaded

It was concluded from the results of the M75AT-AV Mine Non-Propagation Program that zero safe separation spacing [19.7 centimeters (7.8 inches) in centerline distance] utilizing a 7.6-centimeter (3.0-inch) thick 6061-T6 aluminum barrier between mines sufficiently deters the probability of propagating an explosive incident. With the arrangement, the probability of the propagation of an explosive incident is 7.11 percent.

BENEFITS

This project developed new safety criteria which was integrated into safety regulatory documents (DARCOM-385-100) to permit construction of both functional and safe munitions manufacturing facilities. The data generated is derived from realistic testing rather than engineering judgment.

IMPLEMENTATION

The safe separation distance data developed from this project was applied to the designs of LAP lines at Twin Cities AAP and Ford Aerospace.

MORE INFORMATION

Additional information on this project is available from Mr. R. Rindner, AMCOM, AV 880-3828 or Commercial (201) 328-3828.

Summary report, Dec 83, was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **581 4298** titled "**Evaluation of DMN Disposal on Holston AAP B-line**" was completed by the US Army Armament Research and Development Command in January 1983 at a cost of $469,000.

BACKGROUND

Dimethylnitrosamine (DMN) is a potent carcinogen and is on the Environmental Protection Agency's (EPA) list as a toxic or priority pollutant. DMN was discovered in the ammonia recovery discharge column of the Acetic Acid/Ammonia Recovery Unit (B-line) at Holston AAP. The EPA has advised the operating contractor, Holston Defense Corporation, that the DMN concentration should be below 0.5 ppb detection limit for the Holston River. An industrial liquid waste treatment facility was currently under construction to abate the waste streams at Holston AAP. However, the facility did not have the capability to destroy the DMN. Laboratory studies in 1979 indicated that both UV-photolysis and catalytic hydrogenation could be used to reduce the DMN concentration in waste streams. This project was then initiated to further develop the technology for the abatement of DMN at Holston AAP.

SUMMARY

The main purpose of this project was to evaluate advanced alternative treatment technologies for the abatement of DMN. The approach was to develop analytical methods for determining the concentration of DMN and its precursors in the various steams at Holston AAP and investigate methods of treatment for the destruction and inhibition of formation of DMN.

Initially, an analytical method for determining DMN concentrations was developed. This method was based on the use of reverse phase liquid chromatography and was capable of detecting limits of 0.1 ppm DMN. This equipment was installed at Holston AAP and used to analyze the various RDX/HMX manufacturing process streams. Analytical pro^edures were also developed for detecting nitrites. As a result of these studies, nitrites were formed in samples of both RDX/HMX slurry and RDX/HMX dewater. The source was traced back to the Filter and Wash Buildings. Analysis of DMN indicated that the primary source of DMN was the B-line distillation process.

For destruction of the DMN, the use of hydrogenation and ultraviolet (UV) radiation was evaluated. Hydrogenation involved the treatment of the DMN (in solution) with hydrogen heated under pressure in a reactor containing a catalyst. A diagram of the laboratory scale fixed-bed reactor fabricated is shown in Figure 1. The reactor bed (catalyst) was 1-inch diameter by 48-inches long. A mini-pump was used to feed the liquid stream into the reactor. The temperature was controlled by a constant temperature bath at 97°C maximum but could be converted to a steam jacket for temperatures up to 108°C.

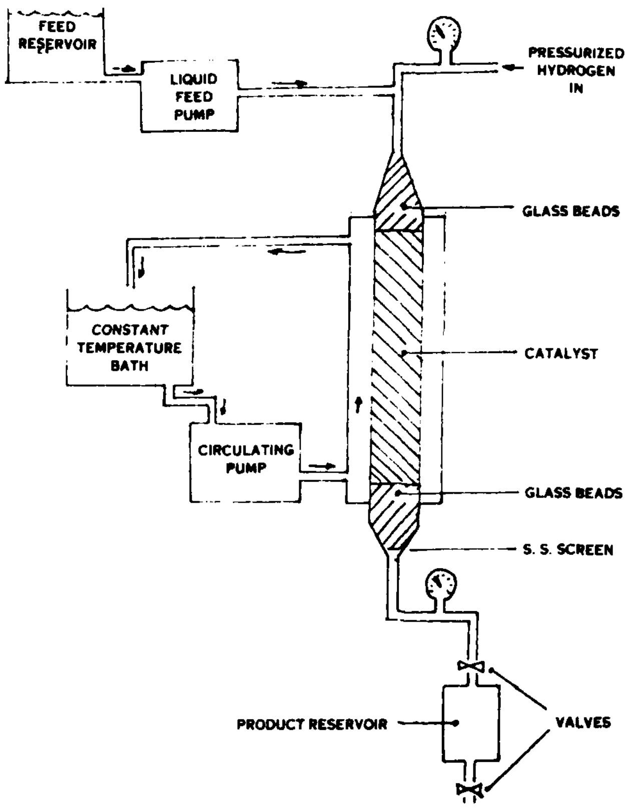


Figure 1 - Laboratory Scale Fixed-Bed Reactor

The results of tests with the fixed-bed reactor indicated higher operating temperatures yielded increased reduction (hydrogenation) efficiency. The reaction was within limits, independent of hydrogen pressure and the trickle-bed mode was more efficient than the flooded-bed mode. In addition, the type of catalyst used was determined by the process stream to be treated. For example, a palladium catalyst at a temperature of 108°C and 150 psig pressure was effective in destroying DMN in the final sludge (B-line, stripping column), A-1 bottoms (Area A, distillation column), Chemical 521 (solution of hexamine in acetic acid), and Chemical 525 (product acid from primary distillation area). A nickel catalyst was used to destroy residual explosives (RDX, HMX) and residual solvents (acetone, cyclohexanone).

Ultraviolet (UV) radiation experiments were performed to determine the degradation products of DMN and RDX/HMX in aqeous solution. The procedure consisted of irradiating a solution of the materials for 2-3 hours. Liquid chromatographic analysis was then performed until no DMN or RDX/HMX was shown. The results of the experiments showed dimethylamine and nitrate to be the products of decomposition of DMN; ammonia, methylamine, nitrite and nitrate were products of the decompositon of RDX/HMX. The destruction, however, was not necessarily permanent since the by-products (dimethylamine, nitrite) could reform to DMN.

The most practical method for DMN abatement was determined to be the catalytic hydrogenation of final sludge. Treatment of the sludge is not only an effective means for DMN abatement but also offers potential savings in manufacturing costs and should avoid the treatment of downstream tributaries (i.e., causticized sludge, A-1 feed, A-1 bottoms, and recovered ammonia) for the removal of DMN.

BENEFITS

This project provided a means for abating the presence of a known carcinogen, DMN, from B-line operations at Holston AAP. Potential savings can be realized by avoidance of treatment of downstream tributaries for removal of DMN.

IMPLEMENTATION

The results generated from this project will be implemented at Holston AAP under a future MCA or MOD Expansion program.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. J. Swotinsky, AMCOM, AV 880-3544 or Commercial (201) 328-3544.

Summary report, Dec 83, was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **580 4309,** Subtask 6, titled "**Process for Molding Rear Seal, 120mm APDS**" was completed by the US Army Armament Research and Development Command in January 1983 at a cost of $919,000.

BACKGROUND

The 120mm GE (German) and 105mm XM774 projectiles utilize a rubber rear seal to prevent propellant gas flow past the projectile base. The technical data package (TDP), as of October 1980, mandated that the seal be molded in place (vulcanized) after assembly of the projectile components. This process requirement does not lend itself to high speed mass production techniques because of excessive manual labor and extremely complex molding processes. The mandated processes also generate an OSHA problem due to the presence of tertiarybutyl perbenzoate (TBPD) which metal parts plants are not equipped to handle.

SUMMARY

The objectives of this task were to examine alternate materials and molding techniques to form a rear seal element and to evaluate methods of bonding the seal to the sabot on the 120mm KE, XM827 projectile. To accomplish these objectives, this task was conducted in three phases, analysis, design, and testing. The technical effort was conducted by Flinchbaugh Products, Inc. (FPI) under the direction of Honeywell, with adhesive evaluation by the Honeywell Plastics Laboratory.

During the analysis phase, the Plastics Laboratory initiated selection of adhesive candidates to bond the silicone rubber seal to the sabot. Five elastomeric silicone adhesives were examined. These candidates were compared to the standard method of vulcanizing the rubber to the metal by butt tensile tests. The following three adhesives exhibited bond strengths equal to or greater than that for vulcanized rubber:

- General Electric RTV 6424
- General Electric RTV 630
- Dow Corning 96-083

On completion of the ring-peel tests, conducted during the design phase, it was concluded that the latter of the three adhesives was to be used.

During this time, FPI designed and fabricated a single-cavity die to mold the rubber seal to the sabot. Initial testing of this die resulted in non-bonding of the seal to the sabot. The die was then modified by Honeywell to include the use of heavier springs to offset the greater than anticipated pressure encountered because the extreme diameter of the rubber seal was being restricted. In addition, the solid one-piece aluminum ring was replaced with a split ring design to facilitate removal after bonding. The FPI and Honeywell fixtures are shown in Figure 1. Using this modified design, molded alternate design rubber seals were bonded successfully to 30 KE slug rounds.

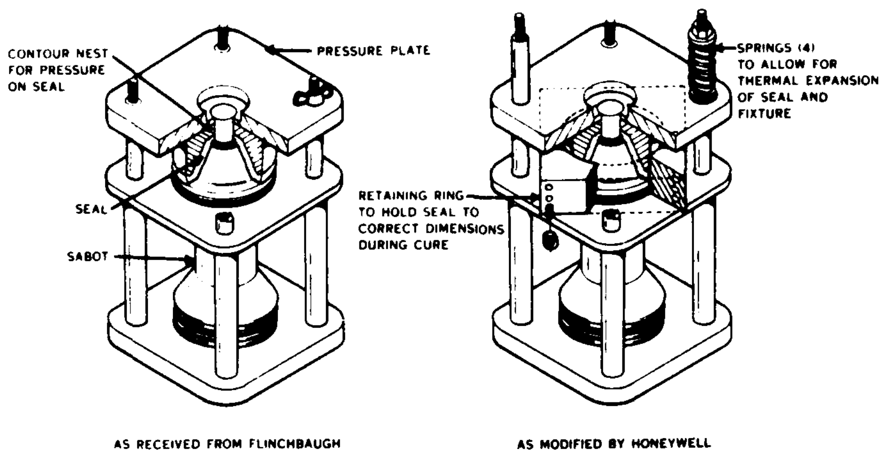


Figure 1 - Bonding Fixture

The completed and inspected KE slug rounds were loaded and subjected to interior ballistic tests to determine if performance had been degraded by the use of the adhesively bonded seals. Test results concluded that the performance parameters were met for the KE slug rounds. Based on these results, 54 XM827 KE rounds with tungsten projectiles were manufactured using the premolded seals adhesively bonded to the sabot. Interior ballistic and dispersion tests of these projectiles also showed no degradation in performance due to the alternate seals.

BENEFITS

The premolded and bonded rubber seal on the XM827 KE projectile performed as well as or better than the vulcanized seal in all functional tests conducted. The process developed in this work is adaptable to high production and a broader base of supply. In addition, the premolded seal bonded to the sabot is 23% less expensive than the present vulcanized process based on 100,000 projectiles per year.

IMPLEMENTATION

Implementation of this concept on the present 120mm XM827 cartridge is not feasible at this time due to limited production requirements. However, this concept can be utilized in the 120mm XM833 cartridge presently undergoing development.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. Gary Nelson, AV 880-4137 or Commercial (201) 724-4137.

Summary report, Dec 83, was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **576 4337** titled **"Investigation of Alternate Materials and Methods for Curing and Molding Processes for Encapsulating Material for ADAM (Area Denial Artillery Munition) Mines M67/M72"** was completed by the US Army Armament Research and Development Command in January 1981 at a cost of $218,000.

BACKGROUND

The M67/M72 mines are the submunitions for the 155mm M692/M731 projectile (ADAM). The curing time for the epoxy encapsulant for these mines is 40 hours and sealing the epoxy plug in the mines requires an additional 40 hours. These long curing times prevent damage to the ammonia battery in the mines by keeping the curing temperature from exceeding 160°F, but equipment and labor costs are high and the production rate is low.

There is a similar problem with the polyurethane encapsulant for the electronic circuitry in the GATOR, GEMSS, and RAAM mines. The maximum allowable curing temperature is also 160°F in order to avoid damaging the lithium batteries used in these mines. This requirement slows output and increases costs. The styrene aeroballistic section for the GATOR mine is molded first and then attached to the mine by adhesive. This is a rather slow and expensive operation.

Earlier work suggested the use of accelerator ATC-3 to reduce the cure time without increasing the cure temperature. Also, ultra-violet (UV) radiation was believed to offer a promising method of reducing cure time without producing unacceptably high temperatures.

SUMMARY

The objective of this project was to investigate promising materials and curing processes with the aim of reducing cure time and maximum cure temperature.

The investigation consisted of three separate phases. In Phase I, the contractor evaluated the effect of ATC-3 accelerator in reducing the cure time of the epoxy used to form the housing of the ADAM mine. The second and third phases were done in-house.

In Phase II, the effect of ultraviolet radiation on the cure time of the polyurethane encapsulant in the GATOR, GEM SS, and RAAM mines was studied. In Phase III, new bonding methods for the GATOR mine and its styrene aeroballistic section were investigated with the object of simplifying the assembly procedure.

The ATC-3 accelerator drastically reduced epoxy cure time in proportion to the amount used. The goal of cutting the time in half was attained. The effect is slightly greater when uranyl acetylacetonate accelerator (UAA) is also present. However, as shown in Figure 1, a serious loss of strength and toughness occurred, both with and without UAA. This strength loss was traced to anhydrides which normally cure the epoxy not fully reacting because of the presence of the ATC-3. In effect, these unreacted anhydrides act as plasticizers. Hence, ATC-3 accelerator was found to be unacceptable.

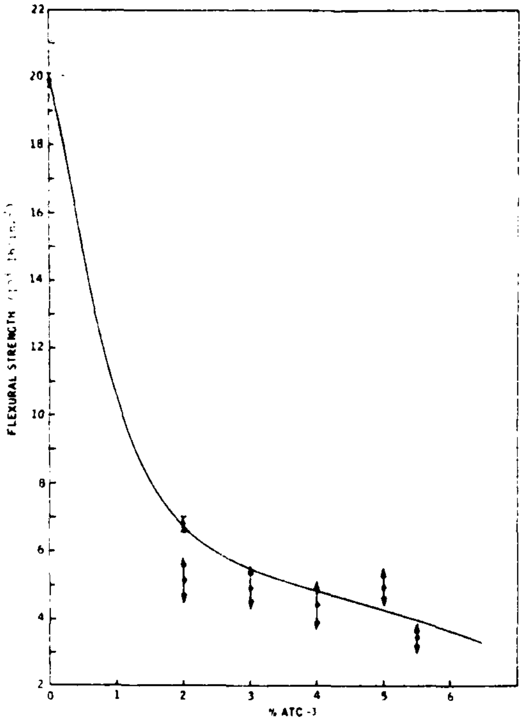


Figure 1 - Flexural strength vs. ATC-3 content in ADAM mine epoxy with UAA

In the Phase II in-house investigation of the effect of ultra-violet radiation on curing the polyurethane in the GATOR, GEMSS and RAAM mines, it was possible to reduce cure time as desired. However, it was also found that the curing process was thermally induced and was not a photo-initiated reaction. The resulting temperature produced was considerably higher than the 160°F permitted and the process, therefore, was not satisfactory.

In Phase III, two types of bonding of the GATOR mine body and its aeroballistic housing were studied. These were mechanical and in-situ. On balance, the latter is the recommended approach. Even so, it was found that either mechanical or in-situ bonding would cost less than the present method. Currently, the mine body and aeroballistic housing are molded separately and then joined with an adhesive. However, new tooling would be required for the change.

BENEFITS

It was expected that all phases of this MMT program would result in reduced production costs. However, only the molding of the aeroballistic section directly to the GATOR mine could result in such a benefit. A reduction in cost from $11.13 to $3.00 or less per GATOR assembly is presently indicated.

IMPLEMENTATION

An in-situ bonding capability for the GATOR mine and its aeroballistic housing should be considered for any facility built in the future for production of GATOR, GEMSS and RAAM mines. Iowa AAP which loads GATOR, GEMSS and RAAM mines now has determined that conversion to an in-situ bonding would not be practical for them. They stated that too much tooling used in common for all three mines would have to be modified and the cost would be excessive.

MORE INFORMATION

Additional information can be obtained by contacting Mr. Donald Vanderbilt at ARRADCOM, AV 880-4536 or Commercial (201) 328-4536. A technical report, ARLCD-TR-80033 titled "Curing and Molding of Plastics Used in Scatterable Mines" was published in May, 1981.

Summary report, Dec 83, was prepared by Wayne Hierseman, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **680 8208** titled **"Material Handling"** was completed by the US Army Armament Research and Development Command in August 1982 at a cost of $18,000.

BACKGROUND

The material handling of gun tubes in the bays of manufacturing buildings at Watervliet Arsenal is done exclusively with large, rail-mounted, overhead cranes. Each crane requires an operator riding in a cab on the crane bridge. Each time a gun tube is moved, a person is required on the floor to attach a sling at the pick-up location and detach the sling at the next location. Movement of gun tubes by overhead cranes is effective only within a bay of a manufacturing building. To move a tube between bays in a building, it is necessary to place the tube on a gun cart, attach a battery-powered "mule" to the cart, and move the cart between bays. All of these operations are labor intensive and time consuming.

SUMMARY

An outside consultant was hired to conduct a survey and make recommendations to improve the material handling to reduce costs. The three recommended alternatives were as follows:

1. Use a masted overhead crane to replace existing cranes and establish a central storage rack in each bay, or

2. Use side loading fork lifts for all moves except machine loading. Machine loading would be done by pendant controlled overhead cranes. Establish a central storage rack in each bay, or

3. Use side loading trucks in conjunction with an automatic guided vehicle system. Have several storage racks in bay areas. Load machine with pendant controlled overhead cranes.

All three recommended alternatives were found to be unacceptable due to marginal return on investment and/or physical space limitations. The side loaders would have required extensive machine relocation in order to achieve the wider aisles required for operation.

BENEFITS

The results of this study could be used in the manufacture of gun tubes. However, a great deal of plant facility costs would be incurred for machine tool relocation and rearrangement in order to set up storage areas and provide adequate aisle space.

IMPLEMENTATION

There are no plans to implement the results of this project at this time.

MORE INFORMATION

Additional information covering this project may be obtained from Mr. Robert Meinhart, US Army Armament Research and Development Command, Watervliet, New York, AV 974-5737 or Commercial (518) 974-5737.

Summary report, Dec 83, was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project 781 8192 titled **"Turbine Engine Productivity Improvement"** was completed by the Troop Support and Aviation Readiness Command in March 1983 at a cost of $1,700,000.

BACKGROUND

AVCO Lycoming Division (ALD) operating the Stratford Army Engine Plant (SAEP), is the prime contractor of the AGT-1500, T-53, and T-55 Turbine Engines supporting both Army aviation and tank production. At the inception of this project, it was recognized that the SAEP physical plant and its equipment were substantially antiquated, as were the manufacturing methods and control systems then being used. The proximate results of this situation were manifested in excessive costs, an inability to meet schedules, and quality problems - particularly on the AGT-1500 engine for the M1 Abrams Tank.

Although there had been some single project approaches to solve problems on a spot basis, there had heretofore been no integrated approach to the solution of the overall problem.

SUMMARY

The objective of this ongoing effort is to improve productivity at the SAEP through reduced costs, enhanced timely deliveries and improved quality. This was to be done by designing and implementing a totally integrated factory operation, including all manufacturing functions, to the "proven-state-of-the-art" level of sophistication. The purpose of this first phase project was to analyze the total manufacturing operation as it then existed (As-Is), and to provide a conceptual design of the future factory (To-Be). See IDEF Model, Figure 1.

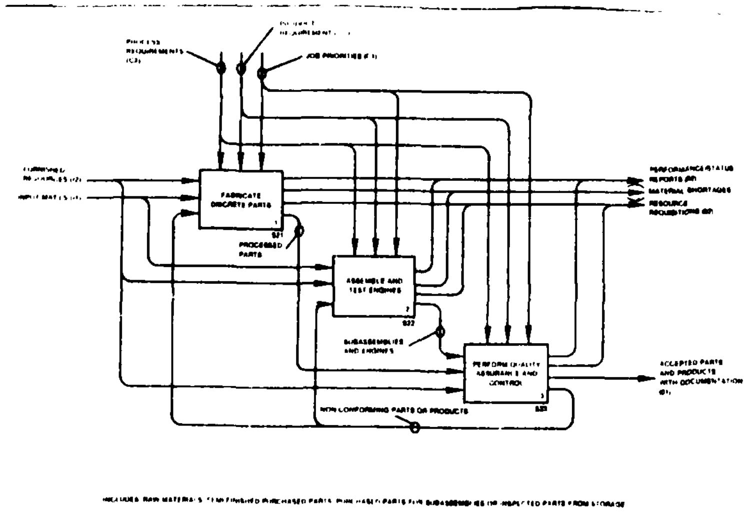


Figure 1 - Produce Products

These analyses and designs were broken down into the categories of Preliminary Needs (As-Is) Systems (As-Is), Fabricate Discrete Parts (As-Is), Assemble & Test Engines and Quality Assurance (As-Is), Systems (To-Be), Fabricate Discrete Parts (To-Be), Assemble & Test Engines and Quality Assurance (To-Be), Receiving Area Conceptual Improvements and Preliminary Design, and Enabling Technologies. Throughout these analyses, a total factory perspective was maintained in identifying and addressing problems to ensure a totally integrated plan for their resolution.

A total of 20 major improvement concepts were developed. Ten concepts dealing with manufacturing information systems were recommended. An additional ten concepts were recommended for improving the fabrication of discrete parts, assembly and test, and quality assurance. A receiving area improvement project and 18 enabling technology projects were also recommended. These recommendations collectively represent a roadmap for realizing an integrated modernization program at the SAEP. The following enumeration of the improvement concepts is included to give the "flavor" of the total program, which is detailed in the 10 volume final report.

<u>Improvement Concepts</u>

1. Engineering/Production Data Control
2. Master Scheduling
3. Requirements Planning
4. Work Order Planning
5. Material Receipt Processing
6. Manufacturing Reporting
7. Management Reporting
8. Factory Support Systemss
9. Integrated Architecture
10. User Education Program
11. Dedicated Manufacturing Centers
12. Modernized Heat Treat Facilities
13. Factory Support Facilities
14. Expanded Cutter Grinding
15. Expanded Receiving Area
16. Kitting of Parts
17. Final Assembly Layout
18. Modernized Test Cells
19. Upgraded Balance Room
20. Quality Data Collection/Analysis

BENEFITS

This first phase project establishes the direction of the entire program by defining the overall problem and recommending an overall solution.

IMPLEMENTATION

The results of this project have been implemented and form the basis for the ongoing effort.

MORE INFORMATION

Additional information may be obtained by contacting Mr. James Corwin of the Troop Support and Aviation Readiness Command at AV 693-2220 or Commercial (314) 268-2220.

Summary report, Dec 83, was prepared by Ken Bezaury, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **E79 3743** and **E81 3743** titled **"Composite Spun Material Traversing Beam for Bridges"** were completed by the US Army Mobility Equipment Research and Development Command (MERADCOM) in August 1983 at a combined cost of $1,495,000.

BACKGROUND

Conventional materials and design approaches for assault bridge launching beams have led to costly fabrication methods. Metallic beams are excessively heavy and exhibit large deflections during launch and vehicular crossings. In order to overcome these problems, beams fabricated from lightweight, high strength composite materials were considered to be essential components of future bridging systems.

The purpose of these MMT projects was to establish manufacturing techniques for graphite/epoxy beam components. The demonstration of the tooling and techniques involved called for the fabrication of bottom chord sandwich panels and one modular composite traversing beam consisting of two ramp assemblies, two rotating links, two connector sections and two center sections.

Project work was accomplished by in-house effort at MERADCOM and contractual effort at the Fiber Technology Corporation (FIBERTEK), Provo, Utah.

SUMMARY

In the bottom chord program, aluminum/graphite epoxy/aluminum sandwich panels were designed, constructed and installed as bottom chords in the 31 meter Rapidly Emplaced Mechanized Bridge (REMB), an all metallic prototype. The panels were constructed of Celion G50 graphite fiber combined with EPON 826 epoxy resin sandwiched between two 7075-T73 aluminum sheets, adhesively bonded to the composite, and cured utilizing a two-step high temperature process.

Fabrication was accomplished by filament winding the fibers onto a flat rotating mandrel which was 25 feet long, 28 inches wide and 6 inches thick. The mandrel was symmetric which allowed the winding of two panels at once. Before winding, 1/8 inch thick aluminum sheets were secured to both flats of the mandrel and covered with an adhesively bonded layer of fiberglass cloth. The mandrel was rotated about its transverse axis to achieve a zero degree fiber angle. Wet winding continued until a 3/8 inch layer of graphite/epoxy was deposited. Another fiberglass cloth layer was placed over the tacky composite. Aluminum sheets that comprise the top skin of the sandwich panels were then emplaced and bonded to the fiberglass layer. At this point, molding and debulking fixtures were attached to the mandrel and panels, one side at a time, and tightened to force out excess epoxy and air. The panels still intact with the mandrel/mold were cured for 2 hours at 200°F followed by 3 hours at 300°F.

The finished panels effectively lowered the weight of the bottom chords by 25 percent while increasing their strength by over 250 percent. With only two panels installed in one 7 meter bay section, the REMB was able to carry a Class 70 load instead of a Class 60 load with no increase in stress levels. The installed panels are shown in Figure 1. The bay section in the photo rests bottom side up.

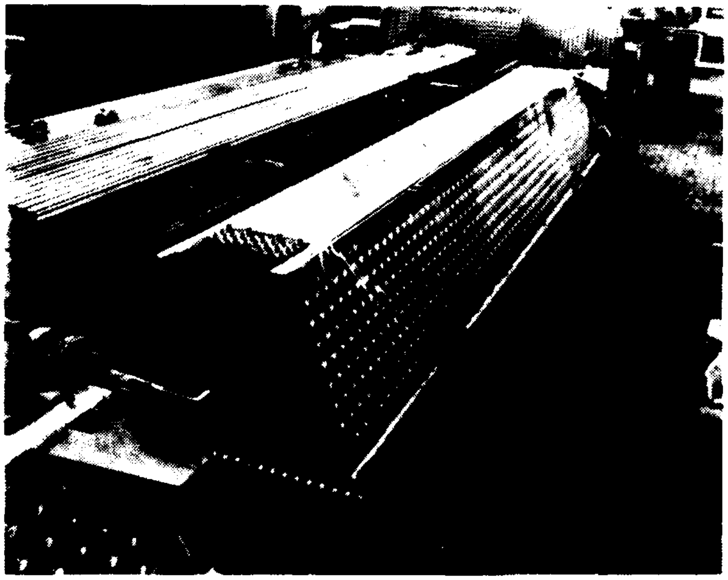


Figure 1 - Composite Panels Installed as Bottom Chords

The traversing beam program was aimed at an all composite non-metallic box beam structure. The hollow beam had upper and lower flanges constructed of helical and uni-longo graphite windings wrapped around foam and honeycomb cores. The side panels were constructed with honeycomb and helical graphite broadgoods. At the heart of the flange construction was the uni-directional, longitudinal winding system adapted from the bottom chord program.

The assembly of the individual beam sections required a myriad of subassembly components to be wound, molded and bonded to produce the final component. The complexity of the launch beam is illustrated by Figure 2.

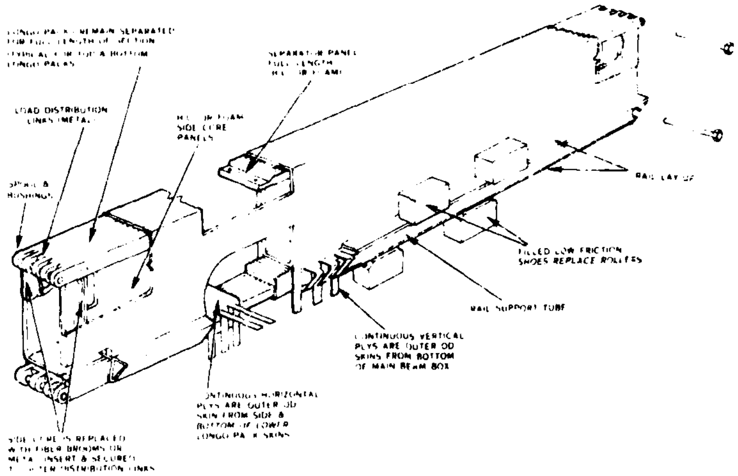


Figure 2 - Launch Beam Orientation Sketch

BENEFITS

The most lasting benefit of this program is the technique evolved for the fabrication of the bottom chord sandwich panels. The vertical winding of the long uninterrupted sections of longitudinally aligned graphite fiber is typical of the fabrication required for common structures such as bridge girders.

IMPLEMENTATION

The traversing launch beam sections and the sandwich panel prototypes were produced using cost effective production techniques. The launch beam program was halted before the process was fully optimized. The prototype articles will not be procured in mass quantities due to the termination of the "Bridging in the 80's" program. In many ways, however, the bottom chord of a military bridge is a generic structure. Future bridges will have bottom chords and the technique developed here will be considered for application. A beginning for the manufacture of composite components for bridge structures has been made.

MORE INFORMATION

Additional information on these projects is available from Mr. Richard Helmke, Bridge Division, Engineer Support Laboratory, Ft. Belvoir, VA, AUTOVON 354-5176/2024 or Commercial (903) 664-5176/2024. The final technical report from MERADCOM is Report 2370 "Advanced Composite Materials in Bridging-Aluminum Graphite/Epoxy Sandwich Panel Installed as Bottom Chord of a Bridge Girder" dated November 1982. The final technical report from the contractor is "The FIBERTEK/MERADCOM Bridge Beam Program" dated May 1983.

Summary report, Dec 83, was prepared by G. Fischer, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **H79 5000** titled **"Production Hot Forging of Alkali Halide Lenses"** was completed by the US Army Night Vision and Electro-Optics Lab (NVEOL) in April 1983 at a cost of $591,000.

BACKGROUND

In 1976, as part of a Defense Advanced Research Projects Agency (DARPA) program for development of high energy laser windows, a significant breakthrough was achieved in forging alkali halide windows of optical quality. Based on the evidence that lens elements could also be produced by forging, DARPA funded NV&EOL to develop forged-to-figure alkali halide optical components for use as a color correcting lens in the SU-103/UA common module infrared (IR) imager. Contract DAAK70-77-C-0128 for this effort was awarded to Honeywell Corporate Materials Science Center in September 1977. Laboratory tests of lens elements made of potassium bromide (KBr) revealed that they possessed the optical qualities needed for use in the imager. Because of the high water solubility of KBr, DARPA also funded R&D efforts to develop an anti-reflective protective coating for use in the 8-12 micron region of the spectrum.

SUMMARY

The Honeywell Ceramics Center was contracted to design and develop the production processes, evaluation processes and equipment necessary to produce a minimum of 300 KBr lenses per month capable of replacing the zinc selenide color correcting lens in the SU-103/UA.

A two-step forging process was the end result of this project. In the first-step forging, the KBr single crystal is hot forged into a strengthened, polycrystalline blank which is preshaped to the diameter required for the second-step forging. The second step forges the first-stage blank between optically polished dies to the final lens specification.

In the R&D process, a double-conical first-stage forging was used. It was found that the double-conical forging tended to wedge in the second-stage forging process. This wedging was alleviated by the use of a plano-conical configuration. The flat side of the forging was placed against the convex Pyrex die in the second-stage forging eliminating the problem while still having single point contact to prevent air entrapment and ensure an outward plastic flow of material.

This plastic flow was enhanced by use of MS-122 fluorocarbon mold-release spray. Other lubrication approaches attempted were teflon and silicone oil. Both of these had unreconcilable problems. Non-lubricated metal dies were also attempted, resulting in the material adhering to the die.

Honeywell purchased the single crystal KBr cylinders from Harshaw Chemical Company, Solon, Ohio weighing 105 grams and having a height-diameter aspect ratio of 1. The aspect ratio and the initial internal strain of the starting crystal were originally thought to have an influence on the residual strain in the forged blank. This was found not necessarily true because starting crystals with aspect ratios as low as .75 and crystals with high internal strain as determined by polariscope have been forged with excellent results.

It was found that the strain rate and not the ram speed should be the controlled parameter during forging. A constant strain rate relates to the constant amount of strain imparted to a given constant volume of material per unit time. A 6% per minute strain rate was used in the first-stage forging resulting in a lower residual strain, less forging time than when a constant ram speed was used, and mechanical strengthening by generating an evenly fine grained (10 to 20 microns) polycrystalline lens blank.

The cylindrical crystals were forged along the <100> direction. The result was a preferential plastic flow in the <110> directions, leading to non-uniform deformation. Cubic starting crystals were tried instead of cylinders but no benefit in strain reduction was realized.

A water polish and methane polish were used to prepare a blank for the second-stage forging. The blank was checked for haze, streaks and defects. The polishing procedure reduces the blank weight to the required 85 ± .5 grams.

Very little reduction occurs in the second-stage forging, shown in Figure 1. Final optical figure and surface finish are the main concerns in this step. Pyrex dies were used to achieve the optical quality. Other die materials such as soda-lime glass and cervit glass were examined with no observable benefit. No lubrication was necessary with the Pyrex dies because of the slow forging speed. Tests show that sound lenses which do not meet the optical figure requirements can be salvaged by reforging.

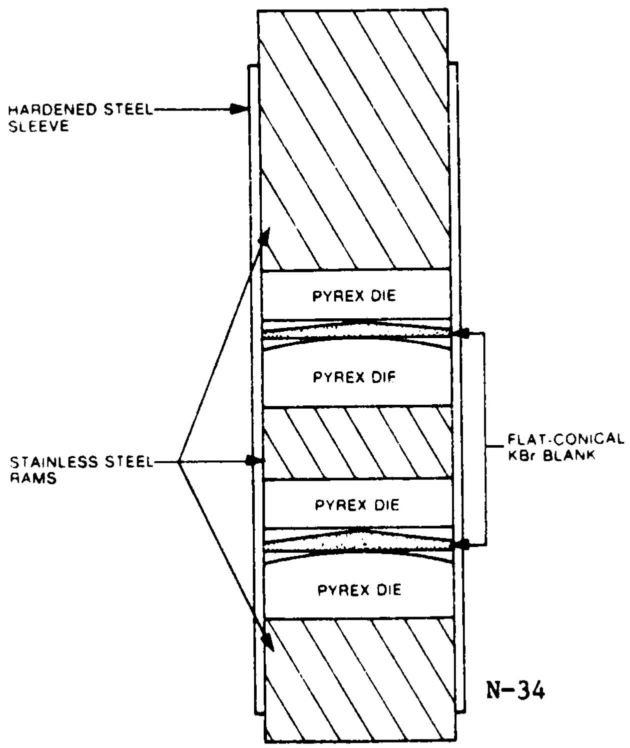


Figure 1 - Second-Stage Forging Assembly/Tooling

BENEFITS

This MMT program to establish a manufacturing method for production of hot forged KBr lenses directly to optical figure and surface finish has met all of its objectives. Low cost, readily available KBr single crystals were hot forged-to-shape with tooling and equipment which can modestly produce 100 lenses in one, eight-hour production shift. This rate is at least six times the original goal of 300 per month. A semiautomatic, computer process controlled system built by Honeywell was used for this purpose. No optical finishing operations were required to meet the optical specifications established for this lens design.

The white light interferometer used as one of the optical evaluation tools was a breakthrough technique. It is a computer automated test procedure which was not only suitable for evaluating the forged optical surfaces of the KBr lens but one which will have wide usage for quickly evaluating optical flats, spherical and most aspherical surfaces.

The contractor estimates that the lower cost of this lens would save the government about $300,000 per year if used in place of the ZnSe lens presently used in the SU-103/UA imager.

IMPLEMENTATION

Implementation has not been effected. While a plasma-polymerized ethane coating and a thallium iodide coating have been developed as moisture resistant anti-reflection coatings, they have not qualified as MIL-STD coatings for KBr. The development of suitable coatings (beyond the scope of this program) has not proceeded to the point where KBr lenses can be deployed for the IR-imaging systems.

MORE INFORMATION

Additional information is available by contacting Mr. William Johnson, NV&EOL, AUTOVON 354-6666 or Commercial (703) 664-6666. A copy of the Final Technical Report is available from DTIC. The contract number was DAAK70-79-C-0138. A paper entitled "Hot Forging and Infrared Lens: Potassium Bromide" was published by the Optical Society of America as page 83-86 in "Workshop on Optical Fabrication and Testing" in 1980. A paper was presented at the 14th Annual Symposium on Optical Materials for High Power Lasers on 19 and 20 November 1982. A paper entitled "Hot Forging of KBr Lenses Directly to Optical Figure" was presented at the 31st National Infrared Information Symposium on 4 May 1983. A video tape describing the manufacturing processes developed is available.

Summary report, Dec 83, was prepared by D. Richardson, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Projects **M75 6370, M77 6370,** and **M78 6370** titled **"Optimization of MMT Program Effectiveness"** were completed by the US Army Materials and Mechanics Research Center in January 1981 at a cost of $191,000.

BACKGROUND

A need was recognized for the assessment of both current and future manufacturing technology in order to establish and/or improve production of combat essential items. It was planned to address this need by establishing a program tailored to specific task areas.

SUMMARY

These projects were funded to accumulate, evaluate, and report information on acquisition costs and manufacturing methods used in the production of military hardware in order to identify potential areas of maximum cost reductions as well as major production obstacles.

A series of technology assessments and cost driver studies were performed. These assessments and studies have helped to identify areas for profitable investment of Manufacturing Technology funds. Areas of application include Missile, Tracked Combat Vehicle, Electronic, Metal Chip Removal Technology and Aviation.

A contract was let with the Center for Manufacturing Technology to determine the US Army's metal-turning requirements in the ammunition and weapons areas during the next ten-year period. The report titled "Needed Developments in Turning Machine Tools" covers the results of a questionnaire, literature search, interface with the Machine Tool Task Force (MTTF), and a telephone survey of Army installations. The conclusions of the report are: (a) the major problem cited by users is maintenance and down-time, (b) the Army's problems are similar to commercial user problems, and (c) the Army plans replacement of about 5 percent (and then only if funding becomes available), while commercial users aim for ten percent.

BENEFITS

The projects aided in identifying potential areas of opportunities for reducing cost and eliminating production obstacles.

IMPLEMENTATION

MMT projects were written and programmed to address areas identified by this project.

MORE INFORMATION

Additional information may be obtained by contacting Mr. R. L. Farrow, US Army Materials and Mechanics Research Center, AUTOVON 955-5519 or Commercial (617) 923-5519.

Summary report, Dec 83, was prepared by J. Bruen, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **R81 1026** titled **"Production of Low Cost Missile Vanes"** was completed by the US Army Missile Command in December 1982 at a cost of $430,000.

BACKGROUND

Control vanes, fins and external rocket and missile fairings are generally fabricated from machined metal castings and forgings. These methods are necessary to meet temperature and strength requirements; however, they have three basic drawbacks: high cost, weight penalties, and long lead times. Application of composite materials offers the potential to overcome all three.

Advances made in the past decade have led to acceptance of composite materials for primary structures on aircraft, missiles, and space vehicles. The cost of these composite structures is becoming competitive with metal structures. To capitalize on composite technology, automated fabrication methods are needed.

SUMMARY

The objective of this effort is to develop automated production techniques and procedures for fabricating low cost missile vanes using high temperature, fiber composites. The effort was divided into two projects, R80 1026 and R81 1026 and oriented to provide data relative to high volume production of the Pershing air vane. The FY 80 project was directed toward establishing the fabrication process. The FY 81 project provided detailed information for automated production processes of a composite air vane. Six major tasks were addressed under the FY 81 project. These included (I) Implementation Plan, (II) Material and Mechanical Property Re-evaluation, (III) Design Refinements, (IV) Tooling Refinements, (V) Manufacturing Process Refinement and Demonstration of Product Readiness, and (VI) Documentation. All tasks were completed. The process flow plan is depicted at Figure 1.

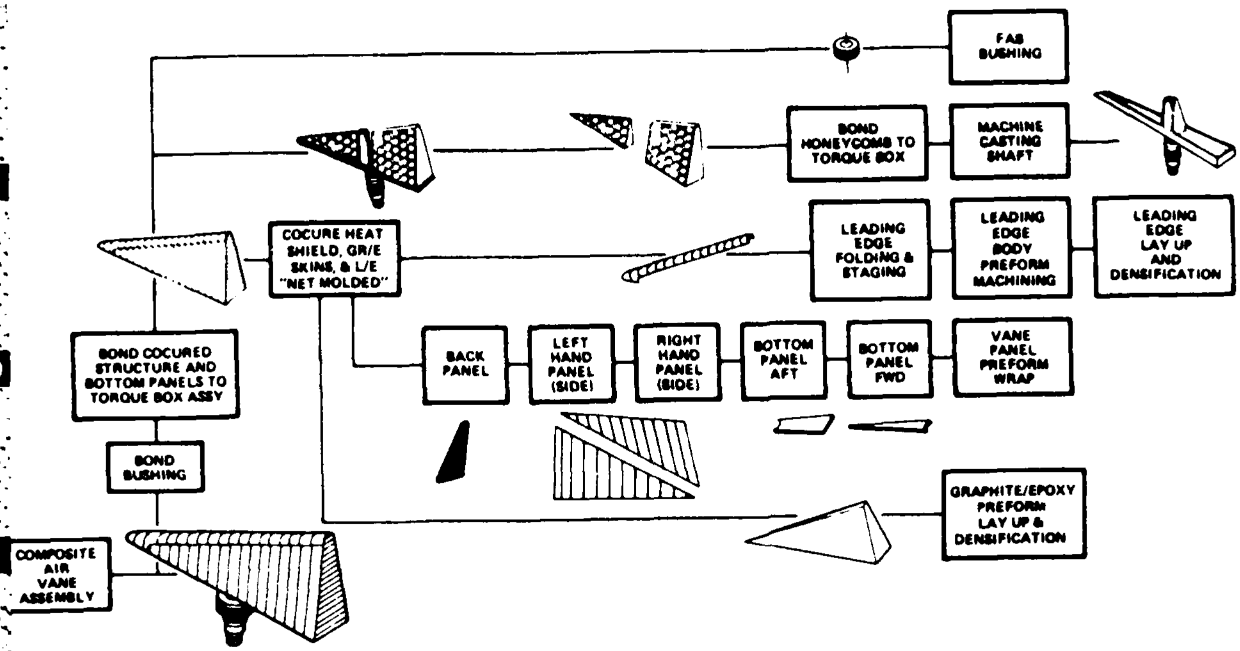


Figure 1 - Process Flow Plan

BENEFITS

It was demonstrated that composite air vanes can adequately replace metallic air vanes. The net molding and cocuring technologies that were developed are directly applicable to other missile systems requiring cocured details. Weight, labor, and material savings are significant by using composite air vanes. The project was recognized throughout the industry as a significant accomplishment.

IMPLEMENTATION

A comprehensive plan to implement the composite air vane into production of Pershing II missiles was developed and submitted as an engineering change proposal (ECP). While the ECP was not approved, certain manufacturing operations developed for the composite air vane will be implemented on the current air vane configuration.

MORE INFORMATION

Additional information and a copy of the Final Technical Report No. OR 16, 949 titled "Manufacturing Methods and Technology Project for Production of Low Cost Missile Vanes" is available from Mr. E. Croomes, US Army Missile Command, AUTOVON 746-1740 or Commercial (205) 876-1740.

Summary report, Dec 83, was prepared by J. Sullivan, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **R79 3381** titled **"Low Cost-Improved 2D Heat Shields"** was completed by the US Army Missile Command in August 1982 at a cost of $500,000.

BACKGROUND

The materials used for heat shields on such items as advanced missiles are tape-wrapped quartz-phenolic, silica-phenolic, and carbon-phenolic. These materials have a good performance record. However, there are several serious drawbacks to continued use in their present form. First, the bias tape has stitched overlap 45° splices at regular increments along the tape length which can affect vehicle stability. Second, significant erosion of present tape-wrapped materials during flight through ice and rain has been observed. Finally, fabrication by tapewrapping is an inherently low-speed, high cost process. Prior aerospace studies indicated that all three could be directionally improved by using a continuous/spliceless prepreg tape for the heat shields.

SUMMARY

The objectives of this program were to develop the manufacturing technology necessary for fabricating low cost heatshield materials using a continuous/spliceless prepreg tape and to demonstrate it by fabricating and evaluating subscale hardware. To be continuous and spliceless required modifying the conventional approach to the problem.

The majority of composite heatshield structures are made by tape wrapping. This essentially consists of wrapping strips of prepregged tape around a mandrel which is representative of the structural shape of the heatshield. (Refer to Figure 1.)

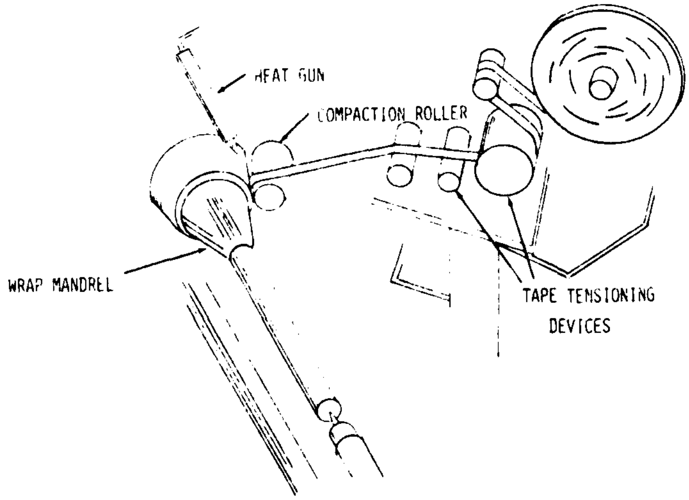


Figure 1 - Schematic of Tapewrapping Process

The mandrels are wrapped at an angle to either the surface or the centerline for aerodynamic, ablation and insulation considerations. To allow the tape to stretch and conform, the materials are made by weaving conventional broadgoods, impregnating with the selected resin system and cutting strips at a 45° angle to the edge of the fabric, (bias-cut). Tapes are subsequently joined by either overlapping or butting the ends, and stitching the overlapped or butted tape lengths. Bias-cut tapes provide the necessary conformance since neither the warp or fill yarns are continuous.

An alternate method for producing tapes is by braiding. The manufacture of fiber reinforced tapes using a braiding approach offers three main advantages. First, the tape can be fabricated at the desired tape width, which eliminates the fabric slitting operation required for conventional bias-cut materials. Second, braided materials can be made continuously, thus eliminating stitching operations. Braiding also provides the capability to tailor the reinforcement in terms of stretch/conformability. Standard commercial braiding equipment can be used to fabricate continuous tapes. Any yarn which can be handled or woven on conventional looms or winding equipment can also be braided.

A series of tasks were undertaken in this program to evaluate and demonstrate the technology of fabricating heatshield materials using braids. The first task was a heatshield material requirements review to enable selection of a heatshield material. The Pershing II ballistic missile was selected as the baseline with specific aerodynamic heating, predicted trajectories and erosion resistance requirements.

The second task was to identify a braid design based on fiber types, fiber volume and physical process characteristics consistent with heatshield requirements.

Next, prepregging procedures were determined based on laboratory equipment and subsequent characterization requirements. In addition to glass reinforced phenolic resin (GRPR), rubber-modified-silica-phenolic (RMSP) material was used. It is cheap, it can be braided, and it can be used on a current US Army missile system.

Test and evaluation procedures were designed to enable a comparison between materials fabricated with braid and conventional bias cut tapes. Finally, subscale heatshields were fabricated for a demonstration.

Heatshield materials were successfully manufactured using braided tapes consisting of RMSP and GRPR. Tests and evaluations consisting of ablation, erosion, thermal and mechanical properties were used to evaluate the performance of heatshield materials fabricated from braided versus conventional bias-cut broadgood tapes. Analyses of test results indicated that heatshield materials wrapped with braided tapes provide similar or improved properties except for mechanical strength. The cause for the lack of mechanical strength was not identified. Drawbacks of braided materials were also identified and related to the selection of braid design and prepregging problems.

BENEFITS

Cost savings may be realized from the application of braiding. Assessment of manufacturing costs indicates that a 5% to 20% savings can be achieved. These savings are the result of eliminating the fabric slitting and stitching operations required for bias materials. Additional cost savings can be realized from reduced scrap. Braided material can be fabricated to very narrow tape widths thus eliminating excess material which must be machined from the final heatshield.

IMPLEMENTATION

The applicability of this technology can be applied to various strategic missile systems for use as heatshields. These systems include Minuteman, MX, Trident, Pershing and Sentry. The technology could also be applied to systems requiring high performance exit cones, but would require material development for this particular application. Materials other than GRPR and RMSP might be used, but, because of critical performance requirements, they must be flight tested. Also, the optimum braid design for each material would be different.

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. Bobby C. Park, AV 746-2147 or Commercial (205) 876-2147. A technical report, "Low Cost 2D Heatshield Materials" dated March 5, 1982, has been prepared.

Summary report, Dec 83, was prepared by Wayne Hierseman, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project **R81 3423** titled **"Low Cost/High Performance Fibrous Graphite Rocket Nozzles"** was completed by the US Army Missile Command (MICOM) in September 1982 at a cost of $300,000.

BACKGROUND

A class of nozzle materials, based on high performance three dimensional (3D) carbon fiber reinforced composites, has been developed for space motor and strategic missile systems for the majority of tactical missile systems; however, premium 3D composites have not provided cost effective performance. Recent developments in carbon-carbon technology have indicated several material concepts that can offer significant cost reductions.

The concepts are based on random carbon fibers in a carbon matrix, and on four-directionally (4D) woven carbon-carbon construction. Both materials are inherently more economical to fabricate than a 3D fine weave carbon-carbon composite. Central to these concepts is the fabrication of relatively large billets of material from which multiple nozzle components can be sectioned and final machined as shown by Figure 1. Tentative cost projections for high volume production of these materials vary from $30 to $60/lb for the random fiber (RF) concept to $80 to $160/lb for the 4D concept.

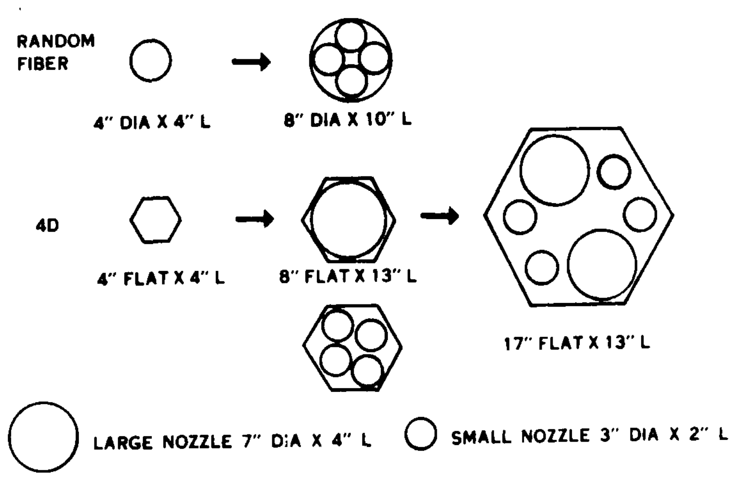


Figure 1 - Carbon-Carbon Billet Configurations

This project, the first year of a two-year program was conducted at Fiber Materials, Incorporated, Biddeford, Maine under contract to MICOM.

SUMMARY

The overall objective of this project was to develop the manufacturing technology necessary for producing low cost carbon-carbon rocket motor thrust materials based on RF and 4D fabrication methods, and to demonstrate refined concepts under conditions representing a pre-production manufacturing mode.

The RF materials employed the use of short discrete fibers which impart mechanical properties sufficient to meet the projected performance requirements of small nozzle (3"D x 2"L) configurations. The baseline RF preform was fabricated by dry blending three parts of pitch based precursor fiber with one part of pulverized phenolic resin. This mixture was warm pressed to 1000 psi in an aluminum mold. The pressed preform was then heat treated (graphitized) under light pressure at 2000°C maximum. Additional process development preforms were fabricated with the inclusion of pitch and polyocrylonitrile (PAN) based fibers of relatively longer length. A wet blending method was also used to achieve greater uniformity during the scale-up effort to an 8 inch diameter preform.

The 4D fiber construction because of its uniform repetitive hexagonal weave geometry should provide quasi-circumferential reinforcement regardless of the size of the nozzle billet or the location from where it is sectioned. The 4D material could be used for both small and large (7"D x 4"L) nozzle configurations. The baseline 4D preform was fabricated by a dry weaving technique considered proprietary by the contractor. Two weave constructions, fine and coarse, employing low cost 2000 and 4000 filament pitch precursor yarns were used. Several process development preforms, incorporating PAN precursor yarns, were also fabricated.

Subsequent processing methods were similar for both the RF and the 4D preforms. The purpose of these procedures was to densify the preform by repeated impregnation with either a resin or pitch precursor. This involved the reiterative process of introducing a liquid impregnant into a porous preform followed by the conversion via pyrolysis, carbonization and graphitization into a graphite matrix.

Twenty billets were fabricated. Based on the thermo-mechanical properties obtained, the RF billets with PAN inclusions tended to have higher strength and total strain than the baseline RF material. However, it was more prone to in-process cracking. Based on the material properties of the 4D billets, it appeared that the all pitch dry woven preform, processed at 15,000 psi during impregnation and carbonization, was the best candidate for future exploitation. A comparison of properties between the fine and coarse weave billet constructions is scheduled for the next program phase.

AD-A139 768 MANUFACTURING METHODS AND TECHNOLOGY PROJECT SUMMARY REPORTS(U) ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY ROCK ISLAND IL DEC 83 3/3

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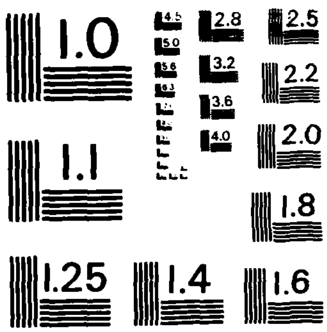
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BENEFITS

The contractor, through evaluation of the RF and 4D billets, determined basic processing parameters that are required for better mechanical strength. The more economical pitch based yarns and short fibers imparted properties that were equal or superior to PAN based materials.

IMPLEMENTATION

Implementation of this project depends upon the results of follow-on MMT Project 3 82 3423.

MORE INFORMATION

Additional information on this project is available from Mr. William Crownover, MICOM, AUTOVON 746-5821 or Commercial (205) 876-5821. The interim technical report from the contractor is TR-RK-CR-83-2, "Low Cost/High Performance Carbon-Carbon Nozzles."

Summary report, Dec 83, was prepared by G. Fischer, Manufacturing Technology Div, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

MMT Project T81 6100 titled "**Engineering Support Directorate Tech Mod Program, Phase I**" was completed by the US Army Tank-Automotive Command in September 1982 at a cost of $100,000.

BACKGROUND

The Engineering Support Directorate's mission to support research and development projects is hindered by Industrial Plant Equipment (IPE) and related Test, Measurement and Diagnostic Equipment (TMDE) that lags state-of-the-art technology. Continuing advances in manufacturing, processing and testing technology also point to a need to constantly update or replace equipment to maintain readiness. Present IPE has an average age of 25 years, some of which requires extensive overhaul or replacement to maintain efficient operation. The absence of state-of-the-art equipment hinders readiness, the ability to provide services economically and reduces mobilization capability.

SUMMARY

A constant investment is necessary in facilities and equipment for modernization to optimize productivity, economically support tank automotive projects and maximize readiness. The best method selected to develop the program was an engineering evaluation of the directorate with emphasis on productivity improvement. The evaluation provided an Industrial Productivity Improvement (IPI) Program which defined an approach to update equipment and facilities, and optimized the organization. The approach for directorate modernization and productivity improvement was developed through a three-phase program. The first phase was to assess the present condition of equipment, facilities, methods and staff. The second was to provide a detailed program to upgrade as necessary, to improve operations and prioritize implementation. The third phase was the actual implementation of the program outlined in the second phase. The major change in the basic IPI concept was in the first phase. This phase developed a scope of work for a contractor to assess the directorate's current status and then develop a Productivity Improvement Program as the second phase. The scope of work developed during Phase I stated that the contractor shall provide a 9-month work effort using a directorate top-down approach utilizing proven and acceptable engineering techniques. The contractor shall conduct a comprehensive study and shall provide a report on the present condition of the directorate with emphasis on design, testing, and fabrication support areas. The study will address future requirements of the directorate to support projected mission requirements. The contractor will then develop a detailed plan for updating the directorate for productivity improvement and will provide a detailed implementation plan for modernization.

BENEFITS

The benefit derived from this project was a scope of work for a comprehensive evaluation of the Engineering Support Directorate, which resulted in a plan for technical modernization of design, test and manufacturing capability.

IMPLEMENTATION

This was the initial project for a multi-year effort; therefore, implementation was not applicable.

MORE INFORMATION

Additional information may be obtained from Mr. Robert Culling, TACOM, AV 786-5162 or Commercial (313) 574-5162. Also, an Interim Report DRSTA-TFP titled "Engineering Support Directorate/Industrial Productivity Improvement Program Phase I" was published on 30 September 1982.

Summary report, Dec 83, was prepared by Bob Hellem, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

APPENDIX I

ARMY MMT PROGRAM OFFICES

ARMY MMT PROGRAM REPRESENTATIVES

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AMCCOM US Army Armament, Munitions & Chemical Command ATTN: DRSMC-IRI-A (R), Ms. Geri Kopp (Ammo) ATTN: DRSMC-IRW (R), Mr. Joseph Pohlman (Wpns) Rock Island Arsenal Rock Island, IL 61299	C: AV:	309 794-3666/3166 793-3666/3166
US Army Armament, Munitions & Chemical Command ATTN: DRSMC-PMP-P (D), Mr. Donald J. Fischer Dover, NJ 07801	C: AV:	201 724-6092 880-6092
US Army Armament, Munitions & Chemical Command Chemical Research and Development Center ATTN: DRSMC-CLR-I (A), Mr. Joe Abbott Building E5101 Aberdeen Proving Grounds, MD 21010	C: AV:	(301) 724-3418/3586 584-3418/3586/3010
AMETA US Army Management Engineering Training Activity ATTN: DRXOM-SE, Mr. Paul Wagner Rock Island, IL 61299	C: AV:	309 794-4041 793-4041
AMMRC US Army Materials & Mechanics Research Center ATTN: DRXMR-PP, Mr. John Gassner Watertown, MA 02172	C: AV:	617 923-5521 955-5521
AMRDL US Army Applied Technology Laboratory Army Research Technology Lab (AVSCOM) ATTN: DAVDL-ATL-ATS, J. Waller Fort Eustis, VA 23604	C: AV:	804 878-5921/2401 927-5921/2401
AVSCOM US Army Aviation Systems Command ATTN: DRSAV-PEC, Mr. Fred Reed 4300 Goodfellow Blvd. St. Louis, MO 63120	C: AV:	314 263-3079/3080 693-3079/3080
BRDC US Army Belvoir R&D Center ATTN: STRBD-HE, Mr. K. K. Harris Fort Belvoir, VA 22060	C: AV:	703 664-5433 354-5433

CECOM
US Army Communications Electronics Command — C: 201 535-4926
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